AIR QUALITY IMPACTS

FRANK CHURCH--RIVER OF NO RETURN WILDERNESS

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May 8, 1996

ACKNOWLEDGEMENTS

Major assistance in preparation and review of this report was provided by the following personnel: Dr. Jim Clayton, USDA-FS, Intermountain Forest and Range Experiment Station, Boise, Idaho; Dr. Alan Galbraith and Linda Merigliano, USDA-FS, Bridger-Teton National Forest, Jackson, Wyoming; Scott Copeland, USDA-FS, Rocky Mountain Forest and Range Experiment Station, Fort Collins, Colorado; Cliff Benoit, USDA-FS, Regional Office (R-4), Ogden, Utah; Dr. Larry St. Clair, Brigham Young University, Orem, Utah, Cathy Copeland, Data Specialist, National Atmospheric Deposition Program, Colorado State University, Fort Collins, Colorado; Dr. Cal Leman, USDA-FS, Salmon, Idaho and Dr. Fred Mangum, Regional Aquatic Ecologist, USDA-FS, Region-4, Provo, Utah.

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FRANK CHURCH--RIVER OF NO RETURN WILDERNESS

The Frank Church--River of No Return Wilderness (FC-RONRW) occupies about 2,370,000 acres in the central portion of Idaho. Elevations range from about 2,000 feet to 10,340 feet. Some portions of the Main and Middle Fork of the Salmon River Corridors are 5,000 feet below the surrounding landforms. Average annual precipitation (rain and melted snow) range from about 15 inches at the eastern and southern canyon bottom locations to 60 inches or more over some of the western mountain areas. Snowfall contributes more than 50 percent of the total precipitation at elevations above 5,000 feet. The average annual snowfall ranges from about 40 inches in the eastern lower canyons to near 200 inches in the higher western canyon and valley areas, and perhaps 400 to 500 inches in the wettest mountain areas. (See Reference 1) The FC-RONRW lies in a transition zone between the maritime climate of the northern and western Idaho and the continental climate of southeastern and eastern Idaho. During the spring and summer seasons, most of the precipitation results from high altitude convectional storms moving from the Gulf of Mexico and the California coast. This includes the air mass movement from the south and southwest, which contains strong pathways of air pollution from California, southwest Idaho, Nevada and southern Oregon. (See Reference #2 and Appendices Map #1) Small particles of sand have been collected in rainfall buckets during the summer rainstorms. These sand particles are in the raindrops, which are possibly from the dust devils and dry lake beds in southwest Idaho and Nevada deserts. Occasional low pressure produces winds from the south and southeast, out of the Salt Lake area, Pocatello and southwest Wyoming which emit more than 300,000 tons of sulfur compounds into the atmosphere annually. (See References #3 and 4 and Appendices Maps #1, 2, 3 and 4) During the winter, the air mass is from the northern Pacific coastal area, which includes Oregon, Washington, Northern Idaho, western Canada and Gulf of Alaska. (See Reference #2 and Appendices Map #1) Data shows that over 100,000 tons of sulfur is released into the atmosphere from Washington, northern Oregon and northern Idaho. (Reference #2 and Appendices Map #1) The latest major drought started around May 1985 and was terminated in the winter of 1994-1995.

VISIBILITY

On July 16, 1989 an automated 35 mm camera was installed on the Middle Fork Peak Lookout (elevation 9,127 feet) that would monitor visibility within the Wilderness. The target site was Big Baldy Mountain located approximately 30 miles west of the site on the Boise National Forest. Visibility is generally excellent during most of the year, except for a few times in the summer due to large wild forest fires. Visibility is affected by suspended particles in the atmosphere, which can be grouped into two categories: fine and coarse particles. Fine particles are less than 2.5 microns such as: sulfate, nitrate, organic carbon, elemental carbon (soot) and other materials. Coarse particles are greater than 2.5 microns, which include soil dust and nearby smoke from forest fires or winter household burning of wood. Sulfate is generally the major component of the fine mass throughout the United States, accounting for 20-40 percent of the mass in the west and 45-60 percent in the east. Sulfur primarily enters the atmosphere as sulfur dioxide gas. The sulfur dioxide converts in the atmosphere to sulfuric acid, which reacts with ammonia gas to form ammonium sulfate. The rate of transformation and the size of the resulting particles depends on the relative humidity. This has a significant impact on visibility, because in high humidity the sulfate particles are larger and scatter light much more efficiently relative to the mass of sulfur. This growth can occur anytime during the life of the particle. If the relative humidity later decreases, the particle will shrink, but not immediately. Therefore the particle size and scattering efficiency depends on the relative humidity of the past as well as the present. Visibility was measured in Standard Visual Range (SVR). Five years of camera monitoring data consistently show background (90th percentile) summer and autumn Standard Visual Ranges of about 268 km and 325 km, respectively. The nature of camera-based SVR measurements tends to overestimate these numbers somewhat; however, the aerosol data suggest that summer and autumn are the two dirtiest seasons annually and that spring and

winter are cleaner than autumn. When the exceptionally clean winter days (as measured by aerosol sampler) are taken into consideration, the use of a very clean 300 km for an annual background screening SVR is reasonable. During the early summer, before forest fires and early to middle fall, visibility can be up to 375 km. The summer five-year average, 50 percent of the time, showed an SVR of 174 km; the fall, five-year average 50 percent of the time, was 215 Km.

At a 50 percent value (the medium value), 50 percent of the SVR observations are less than the 50 percent value, and 50 percent are greater than the 50 percent value.

The 90 percent (good) means that 90 percent of the time, the SVR was less than or equal to the 90 percent value (10 percent of the time, it was greater than or equal to the 90 percent value).

The following visibility data is for this five-year period (See graphs in Appendix):

VISIBILITY DATA RESULTS: Reported in Kilometers (Km)

Summer		**50 percent**	**90 percent**
1989	7/9-8/31	163	261
1990	7/16-8/31	141	239
1991	7/3-8/31	185	262
1992	6/30-8/31	197	290
1993	7/3-8/31	183	287
Average for five-years =		174	268

Fall		**50 percent**	**90 percent**
1989	9/1-10/6	225	330
1990	9/1-10/18	200	262
1991	9/1-10/25	201	324
1992	9/1-10/23	269	375
1993	9/1-10/1	179	335
Average for five years =		215	325

During the time between August 10, 1990 and August 22, 1990 that forest fires were burning on the Boise and Payette National Forests, the Middle Fork Peak Lookout could not see more than a few hundred yards due to thick smoke. The Middle Fork Peak Lookout, located on the east side of the FC--RONRW, started on June 17, 1992 and closed October 4, 1992. During this period, there was 83 days of recorded weather with 66 percent with regional haze and 36 percent with smoke. On August 22, 1992, there was zero visibility as described by the Middle Fork Peak Lookout, which was the same day that the aerosol sampler on South Baldy Mountain recorded a PM-10 value of 63.96 micrograms per cubic meter and the visibility was estimated to be less than 1 mile. This same day, the Salmon valley and other main drainages within the Wilderness had a good visibility range of about 1 mile, fair from 1-3 miles and poor beyond 3-5 miles. In the fall, from September 3, 1991 through October 21, 1991, the visibility ranged from poor to good, depending on wind direction, during the period of the Rush Creek fire within the FC--RONRW on the Payette National Forest.

It is important to understand that one aspect of a visibility monitoring program is inherently long term. Having inventoried visibility conditions for five-six years, a permanent, statistically sound record now exists which can be compared against conditions in 10 or even 100 years.

Though a five-year monitoring project represents a significant effort, it is generally not enough to measure statistically significant trends. This is due to large year-to-year differences which occur normally, and tend to overshadow gradual trends.

DEPOSITION-AIR PARTICULATE AND AIR CHEMISTRY SAMPLING

A Stacked Filter Unit (SFU) particulate sampler was installed in July 1, 1989 on South Baldy Mountain at an elevation of 9,149 feet and operated for five-years during the summer and early fall. This sampler used two sequential filters to measure particles between 2.5 and 10 microns (coarse particles), and those less than 2.5 microns (fine particles). Fine mass compositions on median and clean days tend to be fairly and evenly split between soot, organics, soil and sulfates. Dirty days are dominated by organics, soot, and "other"(possibly more organics, water). The most probable source of the soot and organics is smoke from forest fires and agricultural burning (locally and from the northwest). Concentrations of sulfates and soils remain relatively constant across clean, median, and dirty days. During this time, when fires are producing vast amounts of smoke, the results of a PM-10 equivalent was in the 60's micrograms per cubic meter, in the high mountains. In the valleys and lower drainages, the PM-10 ranged from 128 to 146 micrograms per cubic meter, with visibility at times less than a few miles. During major forest fires burning in August 1992, of 270,000 acres on the Boise National Forest and 14,000 acres on the Payette National Forest, the cumulative impact in the Salmon area for sulfur was 505 nanograms per cubic meter.

Month	Year	Sulfur (nanograms/cubic meter)	
		Medium	Highest
June-August	1989	82	160
September-November	1989	78	134
July-November	1990	97	201
June-August	1991	133	261
September-November	1991	100	192
June-August	1992	135	505
September-November	1992	101	265
June-August	1993	112	251
September-November	1993	121	185
	Average	106	

This figure of 505 is high, considering the five-year average for summer/fall is only 106 nanaograms per cubic meter.

A PM-10 equivalent, five-year summer/fall average was less than 10 micrograms per cubic meter.

AVERAGES FOR PM-10 EQUIVALENT SEASONAL USE

Months	Year	PM-10
July-October	1989	7.2
July-November	1990	9.5
July-October	1991	11.9
June-October	1992	10.5
June-November	1993	9.2
	Average	9.66

During a low pressure in July 1991, with the winds out of the south and southeast, the highest amount for lead measured 4.16 nanograms per cubic meter. The five-year lead average for summer/fall is 0.85 nanograms per cubic meter. A new air monitoring site in northern Utah at Lone Peak Wilderness, measured lead at 1.7 nanograms/cubic meter for the spring of 1994, 2.2 for summer of 1994, 2.2 for fall of 1994 and 3.0 for winter of 1994-1995. There is a 1200 foot high smoke stack located at the Kennecott copper smelter near Magna, Utah, which produces some heavy metals from its operation. This tall stack might be producing materials that end up as long-range transported metals. Also, a steel mill is located near Orem, Utah. These data indicate that northern Utah has a high potential to impact central, southern and eastern Idaho during low pressure systems, such as during July 1991.

In November 1993, the SFU sampler was replaced with an IMPROVE (Interagency Monitoring of Protected Visual Environments) Module A sampler, which is part of a Nation-wide program. The Module A sampler collects particles less than 2.5 microns on a filter, which is analyzed for fine mass and elemental concentrations. This unit operates with the protocols used in the IMPROVE network which allows direct intercomparisons to be made between the Salmon site and approximately 70 other IMPROVE monitoring stations nationwide. This sampler is on loan form the National Park Service.

For 1994, the PM-2.5 averaged 3.1 micrograms per cubic meter. Sulfate is generally the major component of the fine mass throughout the United States, accounting for one-quarter of the mass in the west and roughly one-half in the east. Other data shows that winter fine mass concentrations are consistently very low, even on the 'dirty' days. Overall, fine mass concentrations are similar to those measured at the Bridger and Jarbidge Wildernesses.

This IMPROVE A module has only been operating since November 1993 and it needs to continue for a five-year period, until December 1998. This five-year timeframe will provide an excellent background data base for the area and the State of Idaho. There are only three other sites in Idaho: Craters of the Moon, Scoville (INEL area) and the Sawtooth.

The air quality in the FC-RONRW and the Salmon area is generally quite good compared to other Class I areas in the lower 48 states, as is characteristic of the Idaho region. (See fine mass budget graphs in appendices.)

Two National Atmospheric Deposition Program (NADP) sites, located in Idaho, are near the Frank Church-River of No Return Wilderness boundaries. The Lost Trail Pass NADP site was established in August 1990 and has been operational since October 1, 1990. It is approximately 27 miles **northeast** of the Frank Church--River of No Return Wilderness, on the northern boundary of Salmon and Challis National Forests and the Bitterroot National Forest. It is operated and maintained by the Sula Ranger District of the Bitterroot National Forest in Montana. Atmospheric deposition of particles by precipitation (rain/snow) are collected cumulatively each week throughout the year and sent to the National Atmospheric Deposition Program/ Central Analytical Laboratory at Illinois State Water Survey, Champaign, Illinois, for analysis.

The Smiths Ferry NADP Site is approximately 33 miles **southwest** of the Frank Church-River of No Return Wilderness, midway between Boise and McCall, within the Boise National Forest. It has been in operation since 1984, and is operated and maintained by the Boise Cascade Corporation.

The comparison between Smiths Ferry NADP site on the southwest side of the Frank Church-River of No Return Wilderness and the Lost Trail NADP site, to the northeast of the Wilderness, shows a major difference between the nitrate and sulfate. Nitrate on the west averaged approximately 0.36 mg/l and on the east 0.25 mg/l. The sulfate on the west averaged approximately 0.25 mg/l and on the east side 0.19 mg/l. The pH, nitrate and sulfate shows a consistent trend during the summer period of high nitrate and high sulfate concentration with lower pH in the spring and summer. During the fall and winter, the nitrate and sulfate is lower and pH higher. The pH of both sites were very close, 5.45 on the west and 5.39 on the east.

A recent published report from NADP shows that nitrates have been increasing in our area, and to a lesser extent sulfates, for the period 1985-1993. For the U.S. the trend of increasing nitrates is quite widespread, whereas, the sulfates are generally decreasing throughout the nation. Long-term projections for the western U.S. indicate an increase of nitrogen oxides for the next 20-30 years.

The Lost Trail site averaged 5.5 pH at the laboratory and showed that forty months out of the 55 months were listed as having pH less than 5.6. The field pH average was lower, with a pH of 5.14.

The Lost Trail data show a comparison of NO_3, SO_4, pH and precipitation for monthly averages during the 55 month period of record shows that the atmospheric chemistry trend at the Lost Trail Pass site has been fairly consistent through the period of record.

parameter	10/90--5/92	10/90--5/93	10/90--4/95
NO^3, mg/L	0.28 mg/L	0.24 mg/L	0.25 mg/L
SO^4, mg/L	0.18 mg/L	0.20 mg/L	0.19 mg/L
pH (laboratory)	5.46	5.46	5.39
Precipitation, cm	7.75 cm	7.57 cm	7.67 cm

At the "Smiths Ferry" site, the laboratory pH averaged 5.5 for 119 month period and shows that seventy-six months out of the 119 months were listed as having pH less than 5.6. The field pH average was lower, with a pH of 5.18.

The following data shows a comparison of NO_3, SO_4, pH and precipitation for monthly averages during the 119 month period.

parameter	10/84--4/94
NO_3, mg/L	0.36 mg/L
SO_4, mg/L	0.25 mg/L
pH (laboratory)	5.45
Precipitation, cm	5.7 cm

The Oregon and Washington coastal areas where NADP sites are located are showing acidity in the 5.1 pH range and are the cleanest air stations in the U.S. The other extreme areas are in the northeast, with pH in the 4.1-4.2 range and are the most polluted in terms of acid deposition. The NADP site located in western Wyoming has pH of 4.7-4.8.

Generally the Smiths Ferry site has spring and summer winds and rainstorms out of the south and southwest, with major air pollution out of California (Reference #2 in appendices), southwest Idaho and Nevada. The Lost Trail site also has the same condition, but the distance is approximately 150 miles northeast of the Smiths Ferry site. The wind currents reaching the Lost Trail site passes over the FC-RONRW, which contains the main Salmon River, which is an east to west flowing river with deep canyons. The wind current when it reaches the Lost Trail site would be more diluted and mixed with the wind that travels from the west, up the main Salmon River, along with the fact that the wind would be coming out of western Oregon and southern Washington. Also, during the summer, the wind currents flow north along the Middle Fork of the Salmon River to meet with the main Salmon River. That might explain why the data at Lost Trail site would be lower in sulfate and nitrate amounts. Both the Main and the Middle Fork of the Salmon River are over 5,000 feet below the surrounding mountains, which produces a major wind channel, from the west and south.

SOILS

Soils over much of the FC-RONRW have been developed from granite rocks, which include the quartz monzonites of the Idaho Batholith. Other geology found with the Wilderness is the closely related augen/gneiss rocks of the zones bordering the Idaho Batholith, and true granites of younger age. The next most prevalent geologic group is the volcanics, including andesites, rhyolites and tuff caps which are extensive in the west-central and southeast portions of the Wilderness. The least extensive group is the quartzite. Since the granitics are the most sensitive, it is the main concern group of soil described below. The granite bedrock erodes slowly and forms a thin topsoil (1/2 to 2 inches thick), with pH ranging from 4.4 to 5.1. The high elevation (above 8,000 feet) soils within the "Crags Pluton" contain low base saturation and pH, due to higher precipitation and granite geology.

Soil sample from:

Soil Site 1:	**Base Saturation (percent)**	**pH**
0-1 inch:	32 percent	4.4
1-6 inches:	15 percent	4.1
6-14 inches:	22 percent	4.4
Soil Site: 2:		
0 - 1-1/2 inch:	24 percent	5.1
3-15 inches:	20 percent	5.6

Base saturation was determined using unbuffered ammonium chloride extractable. The low base saturation listed above shows that there is only a limited ability of calcium and magnesium to neutralize the acid.

The two most important elements found in the granitics are calcium and magnesium, and are found to be extremely low amounts.

Exchangeable Calcium	**Milliequivalents per 100 grams**
0-1 inch: (topsoil)	1.5-4.3
1-14 inches: (subsurface)	0.2-1.8
Exchangeable Magnesium	
0-1 inch: (topsoil)	0.2-0.3
1-14 inches: (subsurface)	0.1-0.8

These soils can be affected by air pollution, generally with increased levels of nitric and sulfuric acid, since it has little buffering capacity to neutralize acid deposition.

Soils with low base saturation have a limited ability to neutralize acid deposition. Base cations released during weathering of primary minerals are held on cation exchange sites in soils, and exchange for $H+$ ions (or soil AL^{3+}) resulting from strong acid inputs. Calcium and magnesium are two base cations important in this process, but they are found in very low concentrations in both soils.

LAKE SAMPLING

Lake sampling started in 1985 with the Environmental Protection Agency (EPA) conducting phase one (Western Lake Survey) of a five-year National Water Survey for acid rain effects. Rain and other precipita-

tion is naturally acidic. The acid rain cycle begins with emissions from sulfur dioxide, coal-burning power plants and nitrogen oxide, from vehicles and fossil-fuel power plants. These two gasses, when combined with moisture in the atmosphere, produce sulfuric acid and nitric acid, which is then deposited on the earth as "acid rain" (deposition). Within the Wilderness, nine lakes were sampled for cations, anions, ANC, pH and other measurements. Six lakes are located on granite, two on volcanics and one on quartzite parent material. The results showed that lakes were sensitive to acid rain "deposition" based on their low, acid neunralizing capacity (ANC), and those were located in granitic watersheds. Lake sampling results showed that parent material (geology) is directly related to the ANC, with volcanics generally having higher ANC and pH. Only two of the EPA tested lakes are influenced by volcanics; Falconberry and Marble northwest. Only Dome Lake Watershed consists of the Yellowjacket Formation of metagraywacke and schist parent material. With the increase in elevation and rainfall, some sites that are of quartzite and granite have low ANC and pH. Calcium and magnesium is generally the most important element found in the soil for neutralizing the acid rain effects, such as found in rain and snow. The lower the calcium/magnesium content in the soil, the higher the potential impact of acid rain effects to the ecosystem, such as found in some granite and quartzite watersheds. Since some lakes showed low ANC, a detailed lake sampling program was started in 1989 and has been an ongoing project.

The latest major drought started around May 1985 and was terminated the winter of 1994-1995. The following are the nine EPA lakes sampled in 1985: Golden Trout, Harbor, Skyhigh, Dome, Center Creek (west), Dennis (Middle), Marble (northwest), Falconberry and No Name. Three of the above lakes have been resampled: Golden Trout, Harbor, Ship Island and a non-EPA lake, Wilson in 1994 and 1995. Results show very close similarity to the 1985 Western Lake Survey data. Due to the drought starting in 1985, which produced very low amounts of moisture, the ANC and pH in some of the lakes might be higher than normal years, depending on the geology. During the first spring snowmelt, the runoff is more acidic for a very short time, then after some time, the ANC and pH increases, probably in response to biotic uptake of N and S and due to increased weathering as flow rates decline and water-mineral contact time increases.

Acid neutralizing capacity (ANC) is measured in microequivalents per liter. (See (ANC) graphs in Appendices.)

EPA Lakes Resampled

			ANC	*pH*
Golden Trout Lake:	September	1985	75	7.1
	July	1994	81	6.8
	July	1995	78	6.2
Harbor Lake:	September	1985	42	6.9
	July	1994	38	6.5
	September	1994	37	6.1
	July	1995	25	5.6
	September	1995	35	6.1
Center Cr. (West)	September	1985	98	7.0
	July	1989	90	6.8
Skyhigh Lake:	September	1985	86	7.1
	July	1994	96	6.8
Falconberry Lake:	October	1985	430	7.9
	August	1990	422	7.7

Marble northwest:	October	1985	454	7.7
	September	1990	478	7.8

EPA Lakes Not Resampled

No Name	September	1985	83	7.2
Dennis (Middle)	September	1985	112	7.2
Dome Lake:	September	1985	372	7.8

Non-EPA Lake

Wilson Lake:	July	1995	26	6.0
	September	1995	36	6.0

With less snowpack in 1994, Harbor lake during July snowmelt showed ANC was 38 microequivalents and in 1995 with higher snowpack the ANC in July was 25 microequivalents. This data suggests that under certain conditions, that the spring snowmelt and snowpack has a direct effect to high elevation granitic lakes, by lowering the ANC. When we compare the September 1985 EPA (ANC) for Harbor Lake of 42 microequivalents with September 1994 of 37 microequivalents and September 1995 of 35 microequivalents, we find that over a ten-year period that the ANC is lower, which might be due to the drought conditions or a cumulative impact within the watershed.

Two lakes, Falconberry and Marble northwest are influenced by volcanics and Dome Lake is of quartzite parent material, which all show high ANC and pH of 7.7. Resampling of Falconberry and Marble northeast showed that the lakes did not change over time. Dome Lake will not be resampled due to the non-sensitive nature of the lake. These data show that these lakes are not affected by acid deposition, because of the high amounts of buffering materials like calcium and magnesium. Dome Lake contained 241 microequivalents per liter of calcium and 88 microequivalents per liter of magnesium.

Some lakes pH were lower in July and higher in September, showing that some of the lakes are able to buffer acid rain deposition. In July 1995, Harbor Lake pH was 5.6 and in September 1995, the pH was 6.1, probably due to uptake and weathering as mentioned above. Wilson Lake, which is about hundred yards east of Harbor Lake, had a pH in the lake which remained the same for July and September with a 6.0. Skyhigh Lake in July of 1994 showed a pH of 6.8 and in September 1985 it was 7.1. (See pH graphs in Appendices)

Lake pH

			pH
Harbor Lake:	July	1995	5.6
	September	1995	6.1
Wilson Lake:	July	1995	6.0
	September	1995	6.0
Skyhigh Lake:	July	1994	6.8
	September	1995	7.1

Most of the lakes that were tested for nitrates show the watershed is absorbing most of the nitrate before it reaches the lake. Nitrate that does reach the lake is quickly assimilated by the plankton. Five lakes that were sampled during 1995 shows above detection limits for nitrate.

NITRATE

Barking Fox Lake	1.47 microequivalents
Tango Lake # 31	2.54
Sergent Lake # 220	2.68
Sergent Lake # 221	8.71
Crimson Lake # 32	5.64

On the date sampled, generally mid to late summer, these lakes (listed above under nitrate) would not be expected to have nitrates within detection limits. Alpine lakes in Colorado recently have shown to be in a stage of nitrogen saturation of the watershed. The first indicator that nitrogen saturation is taking place is the occurrence of nitrate levels above detection limits, such as the above listed lake waters, throughout the growing season. A recent published report from NADP shows that nitrates have been increasing in our area and to a lesser extent sulfates for the period 1985-1993. For the U.S. the trend of increasing nitrates is quite widespread, whereas, the sulfates are generally decreasing throughout the nation. Long-term projections for the western U.S. indicate an increase of nitrates for the next 20-30 years. Due to the high nitrates in the above listed lakes, they will be resampled in 1996 to verify the nitrate level. Depending on the results, they may be resampled for long-term monitoring to determine amount of deposition.

As of December 1995 of the 225 lakes sampled since 1989 for acid deposition approximately 14 lakes show Low Sensitivity; 22 lakes are Ultra Sensitive; 11 are Very Sensitive; 40 are Sensitive and 138 are Non-Sensitive. No lakes were listed as acidic.

LAKE SENSITIVE TO ACID DEPOSITION

Acidic	< 0 ANC (acid neutralizing capacity)
Low sensitive	< 50 ANC
Ultra sensitive	< 75 ANC
Very Sensitive	75-100 ANC
Senstive	< 200 ANC
Non-Sensitive	> 200 ANC

MACROINVERTEBRATE SAMPLING

In 1988, Harbor Lake was selected for macroinvertebrate monitoring and sampled as part of the Air Quality Program on the Forest. Macroinvertebrates are part of the food chain in lakes and consists of the following: Mayflies, stoneflies, caddisflies, diptera (two-winged flies), crayfish, shrimp, snails, clams and freshwater earthworms. Biotic impacts to lake ecosystems caused by pH change include changes in reproduction, growth, mortality and species diversity of phytoplankton, zooplankton, microinvertebrates and fish. The ultraoligotrophic lakes chacterisitc of sensitive areas harbor ecosystems which are unique. These ecosystems may be damaged by levels of acidification (pH < 6.5) that may not affect fish at all. Acidic water reduces the bacterial decomposition of debris. Amphipods cannot tolerate pH below 6.0. Many species of stonefles, mayflies and caddisflies die at pH less than 5.0. A few of the macroinvertebrates identified would be good species to use for monitoring sensitivity to pH levels. The Baetid mayfly and Cinygmula mayfly could be an important reference species for monitoring air quality.

Macroinvertebrates can be used as a human activities indicator because it responds to: acid precipitation, heavy metals from mining, vegetation trampling along streambanks, nutrient inputs, including camping near streams and lakes and livestock watering in lakes and streams.

Three stations were sampled in Harbor Lake in August 1988 with the primary purpose to establish baseline data for monitoring air quality. At Station 1, the macroinvertebrate community had fairly good diversity with most of the species tolerant to sedimentation or organic nutrients. There was a moderately tolerant caddisfly species, *Lepidostoma*, that would be a good species for indicating possible habitat degradation.

Other possible indicator species would be the Baetid mayflies found in this community, which are reported to be sensitive to changes in the pH, particularly lower pH levels. They could be excellent indicators for air quality, because they are tolerant to many forms of common disruptions in the environment. If they were indeed sensitive to acid rain or pH depression, they would be extremely important indicator species.

STATION 1

CLASS	ORDER	FAMILY	GENUS	MEAN NO/SQM
INSECTA	EPHEMEROPTERA	BAETIDAE	BAETIS	462.68
INSECTA	EPHEMEROPTERA	BAETIDAE	CENTROPTILUM	53.80
INSECTA	PLECOPTERA			32.28
INSECTA	TRICHOPTERA	LEPIDOSTOMATIDAE	LEPIDOSTOMA	118.36
INSECTA	DIPTERA	CHIRONOMIDAE		2065.92
INSECTA	DIPTERA	CERATOPOGONIDAE	BEZZIA	88.08
INSECTA	MEGALOPTERA	SIALIDAE	SIALIS	398.12
CRUSTACEA	COPEPODA			172.16
PELECYPODA				32.28
OLIGOCHAETA				86.08
ARACHNIDA	HYDRACARINA			774.72
			TOTALS	4282.48

STATION 2

CLASS	ORDER	FAMILY	GENUS	MEAN NO/SQM
INSECTA	EPHEMEROPTERA	BAETIDAE	BAETIS	204.44
INSECTA	TRICHOPTERA	LEPIDOSTOMATIDAE	LEPIDOSTOMA	10.76
INSECTA	TRICHOPTERA	POLYCENTROPODIDAE	POLYCENTROPUS	21.52
INSECTA	DIPTERA	CHIRONOMIDAE		1829.20
INSECTA	DIPTERA	CERATOPOGONIDAE	BEZZIA	21.52
INSECTA	MEGALOPTERA	SIALIDAE	SIALIS	398.12
ARACHNIDA	HYDRACARINA			774.72
			TOTALS	2173.52

At Station 2, Baetid mayflies and the caddisfly *Lepidostoma* could be used as reference species.

STATION 3

CLASS	ORDER	FAMILY	MEAN GENUS	NO/SQM
INSECTA	EPHEMEROPTERA	HEPTAGENI	CINYGMULA	10.76
INSECTA	EPHEMEROPTERA	BAETIDAE	BAETIS	236.72
INSECTA	COLEOPTERA	ELMIDAE		10.76
INSECTA	COLEOPTERA	DYTISCIDAE	HYDROPOROUS	10.76
INSECTA	DIPTERA	CHIRONOMIDAE		1022.20
INSECTA	DIPTERA	CERATOPOGONIDAE	BEZZIA	53.80
OLIGOCHAETA				118.36
ARACHNIDA	HYDRACARINA			312.04
			TOTALS	1775.40

At Station 3, in addition to Baetis, there was a moderately tolerant mayfly, _Cinygmula_ that could also be an important reference species for monitoring air quality. Low diversity and a majority of the species being those tolerant to sediment or organic nutrients was due mainly to low flows and low velocity in the waters sampled.

The aquatic macroinvertebrate biomass at each of the stations was lower than one would expect in a lake with 32 mg/l alkalinity, but there were other limiting factors in these ecosystems.

The Biotic Condition Index (BCI) values in the 70's and mid-60's at these stations indicated just fair conditions in these ecosystems for macroinvertebrate communities, but there were some species present which could be used to monitor and evaluate effects of air quality in this lake ecosystem.

A few of the macroinvertebrates identified above would be good species to use for monitoring sensitivity to pH levels. The _Baetid_ mayfly and _Cinygmula_ mayfly could be an important reference species for monitoring air quality. There was a moderately tolerant caddisfly species, _Lepidostoma_that would be a good species for indicating possible habitat degradation.

It is suspected that some of the results observed in the initial phases of this study may be reflective of the sampling equipment utilized in the capture of aquatic organisms. The modified Surber sampler used for collection of benthic organisms is designed primarily for use in flowing water environments, with the current directing organisms dislodged from the substrate materials into the net bag and preventing their subsequent escape. Use of such a sampler in a stillwater environment would be expected to result in an underestimation of the true benthic community due to the lack of this capturing flow. Without current to deliver food items to the station, benthic organisms as well as fish in lake settings must exhibit more mobility than those required in stream settings to feed effectively. The relative mobility of common lake organisms as amphipods, damselflies, and swimming mayflies provides these species, in particular, a high probability of escape from a Surber-style sampling device.

LICHEN BIOMONITORING

A lichen biomonitoring program was started in 1988 to collect lichens for identification and to determine elemental analysis. Lichens, a symbiotic association between algae and fungi, are possibly the plant group most sensitive to air pollution. Lichens have a long life span, do not have a root system and receive all of their nutrients and moisture from the atmosphere. They have no excretion system and as a result may concentrate both beneficial and phytoxic materials. Lichens have been used as bioindicators to determine severity and extent of air pollution in Europe, Alaska, Wyoming, Colorado and other place within the United States. Over 174 lichen species have been identified since 1988, which do not include the collection from

1995. Two sites were selected, one high-elevation, Golden Trout Lake at an elevation of 8,153 feet and one low elevation, Garden Creek at 3,400 feet, within the eastern side of the Wilderness. The two sites were resampled again in 1993 and found to be very low in copper, lead and sulfur. Other sites were collected in the Wilderness during 1992 and 1993, and the samples are being processed. Data collected in 1988 from Golden Trout Lake and resampled in 1993 show that sulfur from the atmosphere has decreased 32 percent; copper decreased 70 percent; and lead 26 percent. Data collected in 1988 from Garden Creek and resampled in 1993 show copper decreased 42 percent; lead decreased 28 percent and sulfur increased slightly (due to different technique of analysis). The 1988 samples were tested by the "atomic absorption" method and the 1993 samples by the "PIXIE" method. We are currently waiting for results of the lichen samples collected in 1988 to be retested using the "PIXIE" method, so as to compare the results to the 1993 results. Although the sulfur tested at Garden Creek was 0.039 percent, this value is well below the threshold (0.2%) at which damage begins to occur in lichens. (See Lichen Elemental Analysis charts in appendices for updated sites.)

				Elemental Analysis	
Lichen Site	**Elev**	**Date**	**Sulfur**	**Copper**	**Lead**
Golden Trout Lake	8153	1988	0.056%	9.3 ppm	9.1 ppm
	1993		0.038%	2.83 ppm	6.73 ppm
Garden Creek	3400	1988	0.025%	4.9 ppm	7.6 ppm
		1993	0.039%	2.08 ppm	2.17 ppm

Sulfur above 0.2 percent is a potential hazardous concern in lichens. The highest sulfur content in a lichen (Letharia vulpina) within the Wilderness is 0.069 percent at Frog Meadows in 1992. In comparision, the Jarbidge Wilderness in Northern Nevada was from 0.102- 0.226 percent and the Sawtooth National Recreation Area from 0.118-0.179 percent. This decrease in sulfur, copper and lead is related to the mitigation measures on industry required by the Federal Clean Air Act and more unleaded gasoline being consumed. Air particle materials generally flow towards the east and southeast (from the northwest winds) up the Columbia River, into the Snake River drainage and finally up the main Salmon River. Three lichens collected at Garden Creek are from the Pacific Coast: Lecanora pacifica, Tuckermannopsis merrilli and Evernia prunastri. These lichens prove that major winds from the west do bring air particles including spores to the FC-RONRW. Concentration of lead, sulfur and copper in these lichens listed above are all extremely low. Sulfur values are well below the threshold (0.2%) at which damage begins to occur in lichens. There is a great diversity of species and most of those species are abundant. Preliminary elemental analysis results from the two lichen sites show that the lichens in the eastern side of the Wilderness generally are in excellent condition and have not been significantly impacted by air pollution, which indicates that this portion of the area has excellent air quality. More lichen sites need to be analysed for an overall determination of the wilderness air quality, especially on the west side of the wilderness, from indications of higher sulfates and nitrates with the NADP monitoring.

BRYOPHYTE SAMPLING

Bryophytes which include mosses and liverworts were collected starting in 1992, for species identification. Approximately 75 mosses and three liverworts have been identified to date, but does not include collection from 1995. Mosses, like lichens, absorb trace elements directly from the atmosphere and accumulate in the tissue. Four species of mosses have been identified within the Wilderness that are common on the Coast Ranges of central California and possibly Oregon. These four species are: Anacolia menziesii, Antitrichia curtipendula, Hedwigia sp., and Metanecken menziesii. This identification along with three lichens from the Pacific Coast indicates that we do receive the winds from the west. Identification of species collected from 1995 should be available in a few months. Two species which could be used for determining

water quality in streams are: Scouleria aquatica and Tortula ruralis. These species along with other baseline information will provide a good data base for long-term biomonitoring within the Wilderness.

RESULTS FROM AIR MONITORING PROGRAM AND RECOMMENDATIONS

Data collected from rain and snow over the past years from the Smiths Ferry and Lost Trail Pass NADP sites show that most of time, the pH is less than 5.6. This evidence indicates that the Wilderness is being impacted from outside Idaho. The year-round aerosol sampling with the IMPROVE A module needs to continue until December 1998. This five-year period will provide an excellent data base for the Forest, State of Idaho and the Nation-wide network program. This information is required for the Forests projects, such as, baseline information, prescribed burning, EA and EIS's. Lichen biomonitoring sites that were sampled in 1988, have been resampled in 1993 for elemental analysis and are listed in the above report. The 1991 sites were resampled in 1995 and we are waiting for elemental analysis. Sites that were sampled in 1992-1995 need to be resampled over 4-5 year increments for a complete data base of the Wilderness. Sites to be sampled this summer (1996) will also need to be resampled in five years. Lake sampling for chemical analysis needs to continue to obtain baseline information and to select specific lakes for long-term monitoring of impacts. The only measurable effects on lakes at this time is from some high elevation granitic lakes with low ANC and pH which shows the potential for impacts. Macroinvertebrate inventories are a good tool for monitoring streams. If used in lakes, a drag net sampling should also be utilized with the Surber sampler to provide a better indication on quanity of macroinvertebrates. The reason Harbor Lake was sampled is because the small creek from Harbor Lake into Wilson Lake was dry. Harbor Lake inlet and outlet need to be sampled to determine baseline information. The lake needs to be resampled along with a drag net to determine any effects within the lake system. Only one lake was sampled and this does not provide any comparsion to other lakes within the Wilderness. A few of the macroinvertebrates which were identified would be good species to use for monitoring sensitivity to pH levels. The *Baetid* mayfly and *Cinygmula* mayfly could be an important reference species for monitoring air quality. There was a moderately tolerant caddisfly species, *Lepidostoma* that would be a good species for indicating possible habitat degradation. Other lake inlet and outlets need to be identified according to lake pH and ANC, and then sampled for macroinvertebrates to determine the long-term effect from air pollution. The long-term biomonitoring of the following will provide a baseline and impacts to the ecosystem: lichens, bryophytes, macroinvertebrates, air particle analysis and lake chemistry.

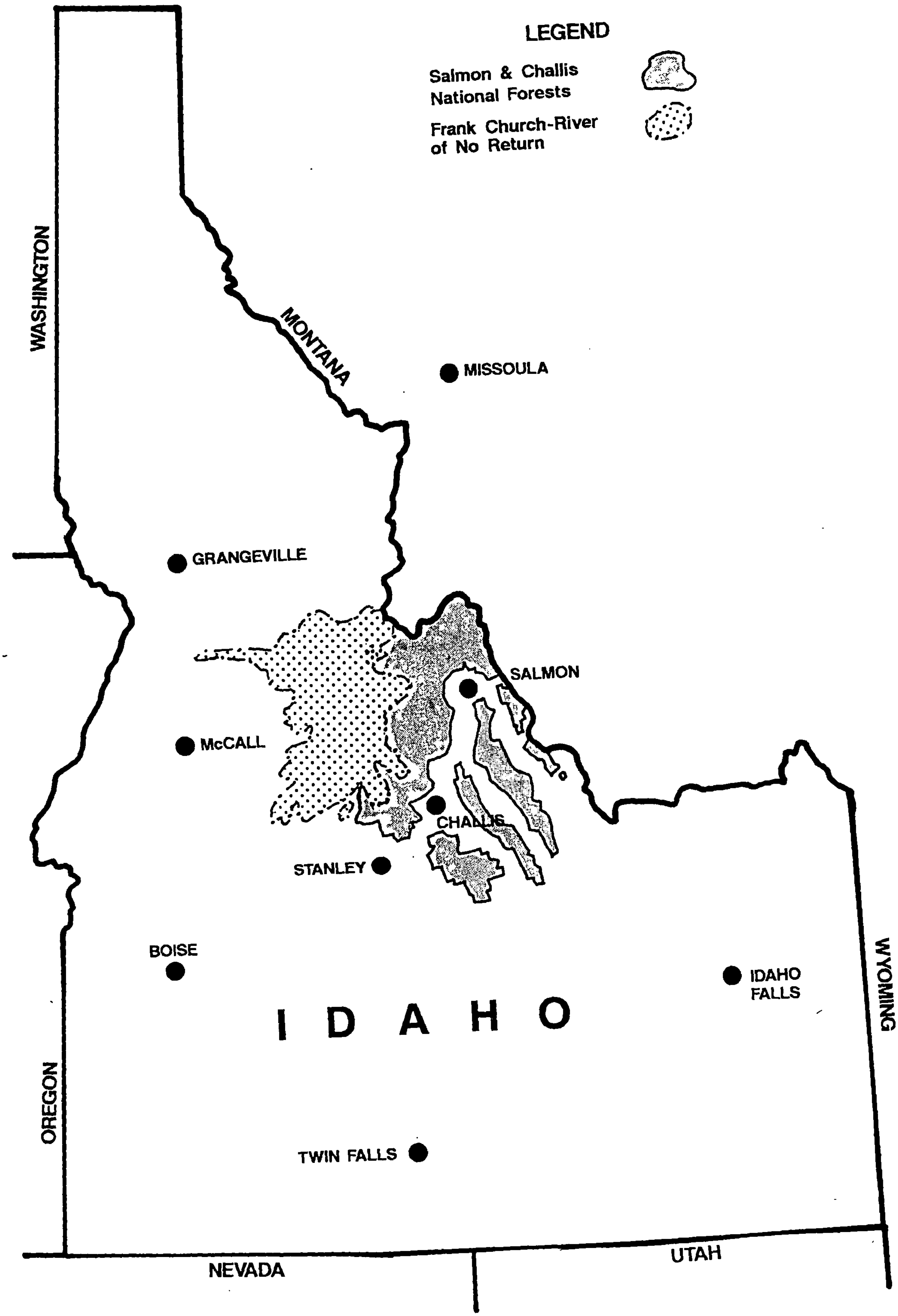
REFERENCE

1. Climate of the Frank Church--River of No Return Wilderness, Central Idaho; Arnold I. Finklin, USDA-FS Intermountain Research Station, General Technical Report INT-240, March 1988.

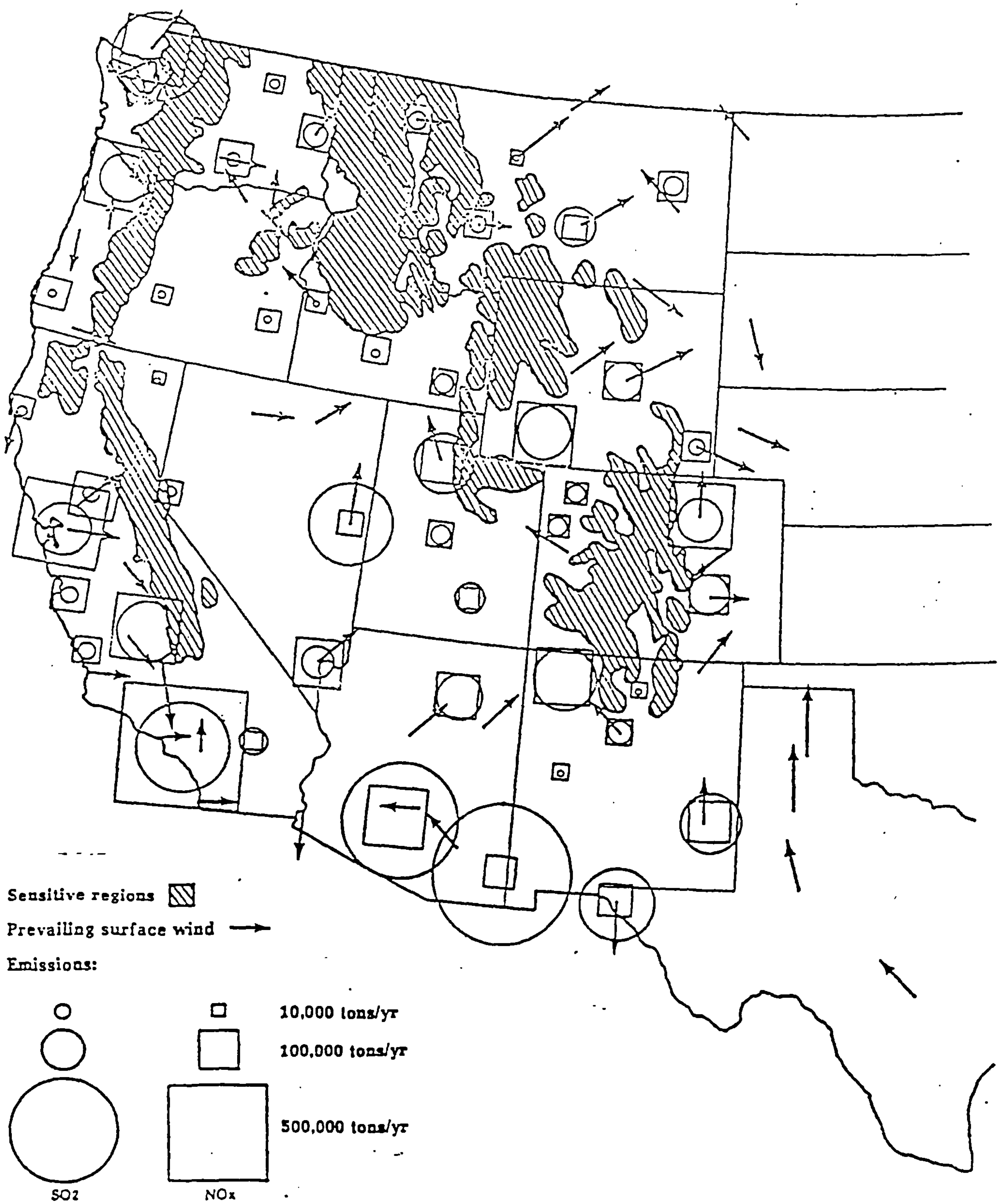
2. Origins of Sulfur-Laden Air at National Parks in the Continental United States; Bresch, Reiter, Klitch, Iyer, Malm and Gebhart. Transactions; Visibility Protection: Research and Policy Aspects, by Prem S. Bhardwaja, Editor, an APCA speciality conference, Grand Teton National Park, Wy, September 1986.

3. Workshop Proceedings; Air Quality and Acid Deposition Potential in the Bridger and Fitzpatrick Wilderness,USDA-FS, Intermountain Region (Air Quality Group), Ogden, Ut, March 1984.

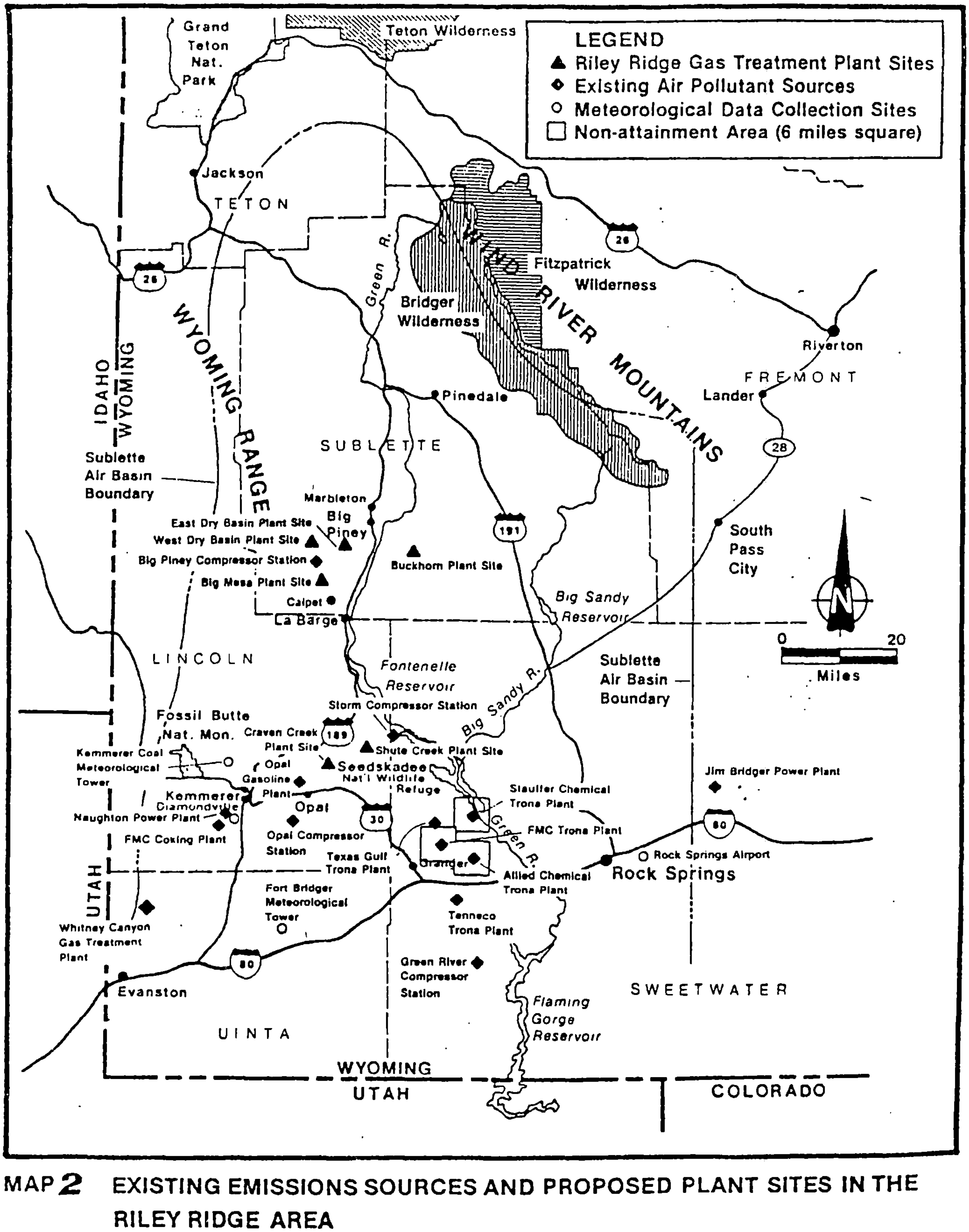
4. Emission Sources and Prevailing Winds in Relation to Sensitive Regions in the West; Sensitive Regions - (EPA), Emissions - (EPA-NEDS) and Prevailing Winds - Climate Atlas of the United States.


LEGEND
Salmon & Challis National Forests
Frank Church-River of No Return
WASHINGTON
MONTANA
MISSOULA
GRANGEVILLE
SALMON
McCALL
CHALLIS
STANLEY
BOISE
IDAHO
IDAHO FALLS
WYOMING
OREGON
TWIN FALLS
NEVADA
UTAH

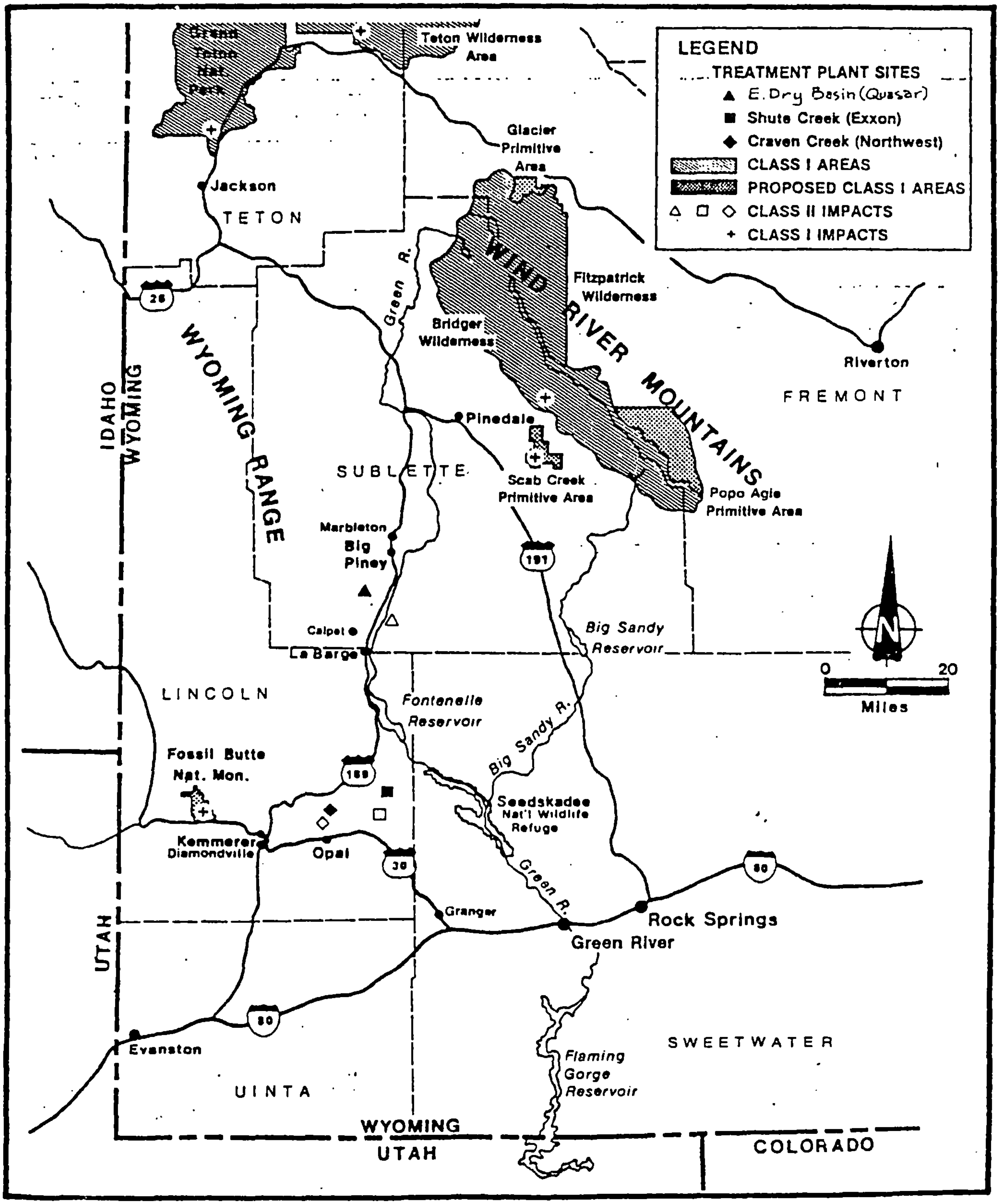
Emission Sources and Prevailing Winds in Relation to Sensitive Regions in the West



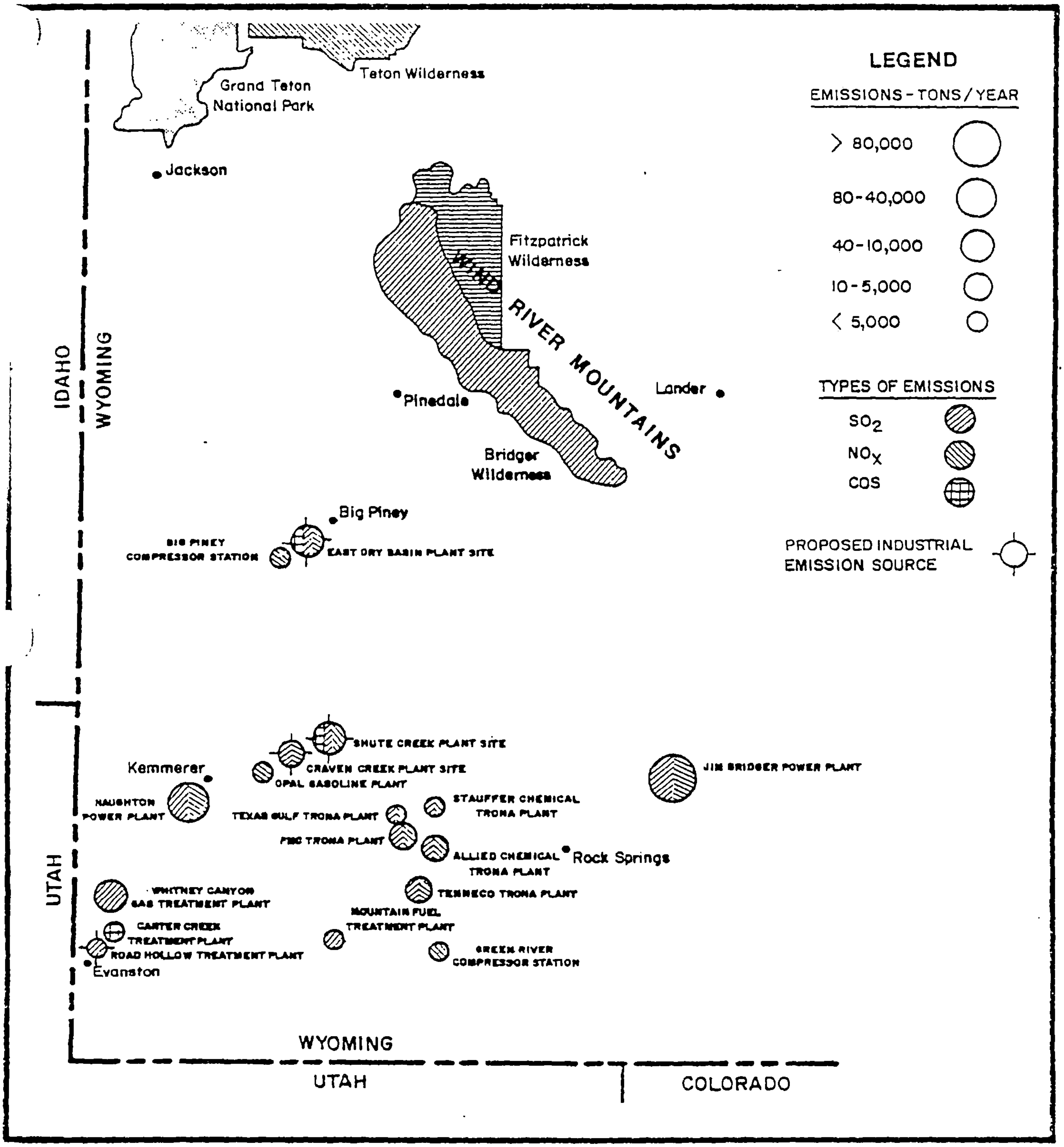
Sources: Sensitive regions — chapter 3 (EPA)
Emissions — chapter 4 (EPA-NEDS)
Prevailing winds — Climatic Atlas of the United States



MAP 2 EXISTING EMISSIONS SOURCES AND PROPOSED PLANT SITES IN THE RILEY RIDGE AREA



MAP 3 LOCATIONS OF MAXIMUM 24-HOUR AVERAGE SO_2 CONCENTRATIONS IN PSD CLASS I AND CLASS II AREAS FOR THE SHUTE CREEK ALTERNATIVE



MAP 4 EXISTING AND PROPOSED SOURCES OF ACID PRECURSORS

AIRS FACILITY SUBSYSTEM QUICK LOOK REPORT

ESTIMATED EMISSIONS - 1000 TONS/YR AND OVER (SO2)------

DATE: 08/05/93 STATE PRIVATE AND CONFIDENTIAL AND DRAFT SIF DATA INCLUDED

STATE	CO.	#	CLASS	PLANT NAME	STREET	CITY NAME	SIC	YINV	PLLT	EST. EMIS	TONS/YR
MT	049	0001	A1	ASARCO - EAST HELENA	P.O. BOX 1230	EAST HELENA	3332	92	SO2	18251.0500000	TY
	087	0008	A1	MPC - COLSTRIP 1-4	P.O. BOX 38	COLSTRIP	4911	92	SO2	10504.0000000	TY
	111	0013	A1	EXXON CO USA	700 EXXON ROAD	BILLINGS	2911	92	SO2	10041.0000000	TY
		0015	A1	MPC - CORETTE/BIRD POWER PL	PO BOX 30495	BILLINGS	4911	92	SO2	9012.0310000	TY
		0012	A1	CENEX	US 212, SOUTH OF LAUREL	LAUREL	2911	92	SO2	8533.3570000	TY
		0014	A1	MONTANA SULFUR & CHEMICAL	EAST FRONTAGE ROAD	BILLINGS	2819	92	SO2	3326.8800000	TY
		0011	A1	CONOCO	401 S 23RD ST	BILLINGS	2911	92	SO2	2215.6120000	TY
	029	0012	A1	COLUMBIA FALLS ALUMINUM	2000 ALUMINUM DRIVE	COLUMBIA FALLS	3334	92	SO2	1681.7150000	TY
	013	0004	A1	MONTANA REFINING	1900 10TH STREET	BLACK EAGLE	2911	92	SO2	1676.2300000	TY
	087	0007	A1	ROSEBUD POWER PLANT	P.O. BOX 189	COLSTRIP	4911	92	SO2	1138.1540000	TY
UT	015	0001	A2	ENERGY WEST MINING - DES BE	NO STREET ADDRESS	ORANGEVILLE	4911	85	SO2	12298.9900000	TY
	007	0002	A1	UPL CASTLE GATE	HWY 6 & HWY 191	HELPER	4911	90	SO2	6766.1380000	TY
	015	0003	A2	JOHNSON ASPHALT	NIELSON PLANT	HUNTINGTON	2951	85	SO2	5979.9970000	TY
WY	009	0001	A1	PACIFIC P&L-DAVE JOHNSON	1591 TANK FARM ROAD	GLENROCK	4911	91	SO2	27274.0600000	TY
	037	1002	A1	PACIFICORP - JIM BRIDGER	PO BOX 158	POINT OF ROCKS	4911	92	SO2	21592.2400000	TY
	023	0004	A1	PACIFICORP NAUGHTON POWER P	PO BOX 191	KEMMERER	4911	92	SO2	17569.0100000	TY
	031	0001	A1	BASIN ELECTRIC LARAMIE	LARAMIE RIVER PLANT	WHEATLAND	4911	91	SO2	7008.6800000	TY
	005	0046	A1	PACIFIC P&L WYODAK	3 MI E OF GILLETTE	GILLETTE	4911	91	SO2	6664.9990000	TY
	041	0012	A1	AMOCO WHITNEY CANYON	20 MI NNE EVANSTON	EVANSTON	1311	91	SO2	5983.5640000	TY
	007	0001	A1	SINCLAIR OIL CORP	BOX 277	SINCLAIR	2911	91	SO2	5917.0000000	TY
	037	0004	A1	FMC TRONA	PO BOX 872	GREEN RIVER	1474	91	SO2	4794.5760000	TY
		0002	A1	GENERAL CHEMICAL	PO BOX 551	GREEN RIVER	1474	91	SO2	4195.9990000	TY
	045	0005	A1	BLACK HILLS OSAGE	OSAGE POWER PLANT	OSAGE	4911	91	SO2	3007.9980000	TY
	013	0011	A1	ARCO OIL & GAS	6 MI SE OF RIVERTON	RIVERTON	1311	91	SO2	2010.0850000	TY
	025	0005	A1	LITTLE AMERICA REFIN	PO BOX 510	EVANSVILLE	2911	91	SO2	1899.3000000	TY
	021	0001	A1	FRONTIER OIL & REFIN	FORMERLY HUSKY	CHEYENNE	2911	91	SO2	1520.8280000	TY
	023	0001	A1	FMC COKING PLANT	PO BOX 431	KEMMERER	2999	91	SO2	1194.3000000	TY
	025	0002	A1	AMOCO REFINERY	PO BOX 160	CASPER	2911	91	SO2	1153.2200000	TY
	013	0008	A1	AMOCO BEAVER CREEK	13 MI SE OF RIVERTON	RIVERTON	1311	92	SO2	1108.7310000	TY
	029	0012	A1	AMOCO ELK BASIN	10 MI NW OF POWELL	POWELL	1311	91	SO2	1095.5800000	TY
	023	0013	A1	EXXON SHUTE CREEK I	13 MI NE OF OPAL	KEMMERER	1311	91	SO2	1078.0060000	TY
	001	0002	A1	MOUNTAIN CEMENT CO	PO BOX 339	LARAMIE	3241	91	SO2	1020.0000000	TY

TOTAL NUMBER OF LINES: 32

AIRS FACILITY SUBSYSTEM QUICK LOOK REPORT

ESTIMATED EMISSIONS - 1000 TONS/YR AND OVER (SO2)------

DATE: 08/05/93 STATE PRIVATE AND CONFIDENTIAL AND DRAFT SIP DATA INCLUDED

STATE	CO.	#	CLASS	PLANT NAME	STREET	CITY NAME	SIC	YINV	PLLT	EST. EMIS	TONS/YR
AZ	005	0004	A1	SRP - NAVAJO GENERATING STA	PO BOX W 5MI. E. OF PAG	PAGE	4911	90	SO2	90767.6100000	TY
	007	0004	A1	ASARCO INCORPORATED	640 HAYDEN AVENUE	HAYDEN	3331	90	SO2	42663.6200000	TY
	017	0001	A1	APS-CHOLLA POWER PLANT	PO BOX 188	JOSEPH CITY	4911	90	SO2	15193.0000000	TY
	019	0021	A1	PHELPS DODGE	NEW CORNELIA MINE	AJO, STATE ENF	1021	85	SO2	14222.0000000	TY
	021	0032	A1	MAGMA METALS COMPANY-SAN MA	200 S. REDDINGTON ROAD	SAN MANUEL	3331	90	SO2	12552.9500000	TY
	001	0004	A1	SPRINGERVILLE GENERATING ST	PO BOX 2222	SPRINGERVILLE	4911	90	SO2	8756.0000000	TY
	017	0007	A1	STONE CONTAINER CORPORATION	SPUR ROUTE 277	SNOWFLAKE	2611	90	SO2	8536.2000000	TY
	001	0003	A1	SRP - CORONADO GENERATING S	ST HWY 666, 7MI N OF ST	ST. JOHNS	4911	90	SO2	7319.0000000	TY
	003	0002	A1	AEPCO APACHE GENERATING STA	HIGHWAY 191/666 SOUTH	COCHISE	4911	90	SO2	7044.4300000	TY
	007	0006	A1	CYPRUS MIAMI MINING CORP	HWY 60	CLAYPOOL	3331	90	SO2	4141.1590000	TY

TOTAL NUMBER OF LINES: 10

AIRS FACILITY SUBSYSTEM QUICK LOOK REPORT

ESTIMATED EMISSIONS - 1000 TONS/YR AND OVER (SO2)------

DATE: 08/05/93 STATE PRIVATE AND CONFIDENTIAL AND DRAFT SIP DATA INCLUDED PAGE: 2

STATE	CO. #		CLASS	PLANT NAME	STREET	CITY NAME	SIC	YINV	PLLT	EST. EMIS	TONS/YR
NV	003	P001	A1	SOUTHERN CALIFORNIA EDISON	2700 EDISON WAY	LAUGHLIN	4911	90	SO2	16754.0000000	TY
	013	0001	A1	SIERRA PACIFIC POWER COMPAN	6100 NEIL ROAD, P.O. BO	RENO	4911	85	SO2	9614.0000000	TY
	003	P002	A1	NEVADA POWER COMPANY	P.O. BOX [illegible]	MOAPA	4911	90	SO2	4914.0000000	TY

TOTAL NUMBER OF LINES: 3

AIRS FACILITY SUBSYSTEM QUICK LOOK REPORT

ESTIMATED EMISSIONS - 1000 TONS/YR AND OVER (SO2)------

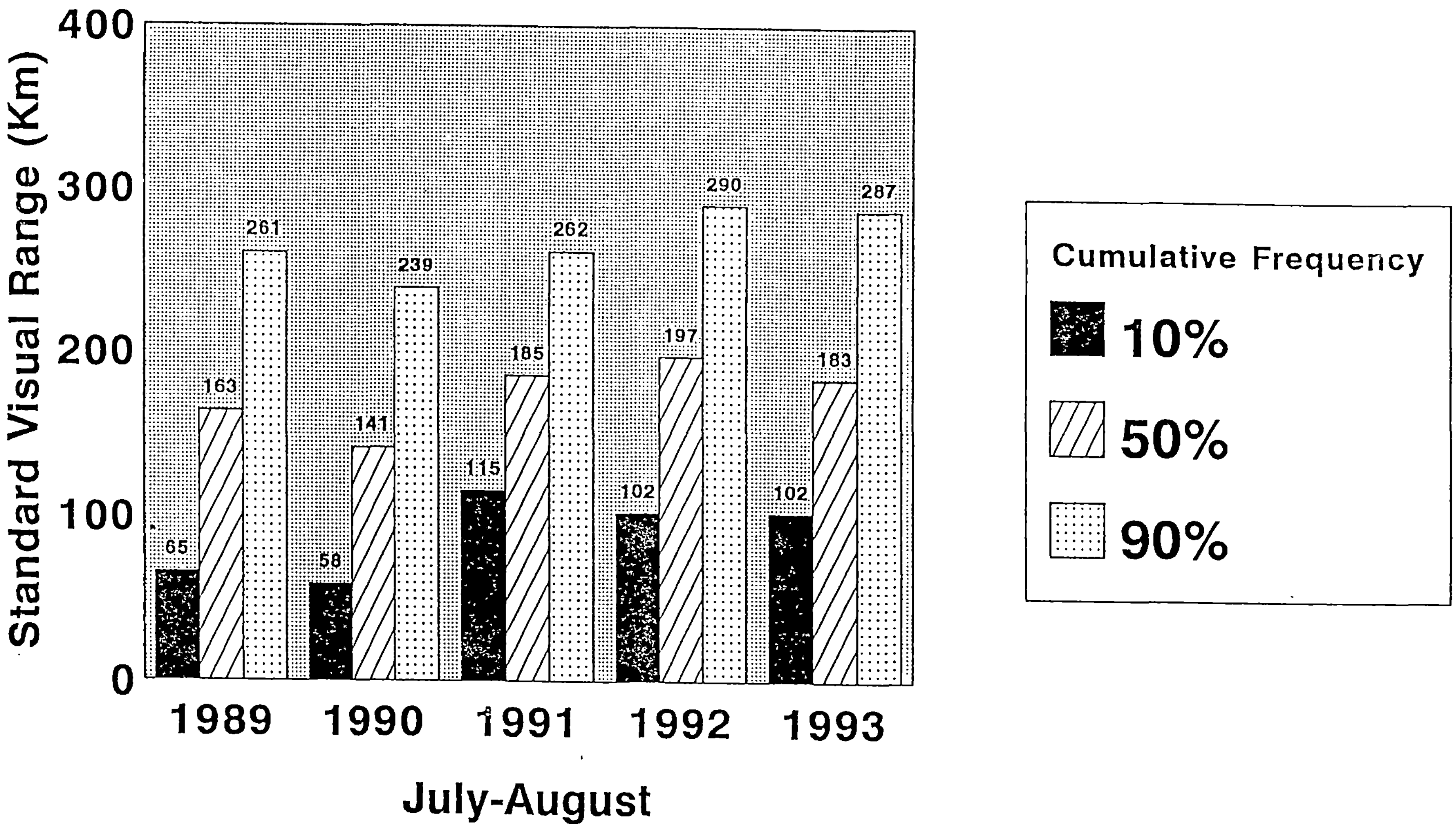
DATE: 08/03/93 STATE PRIVATE AND CONFIDENTIAL AND DRAFT SIP DATA INCLUDED

STATE	CO.	#	CLASS	PLANT NAME	STREET	CITY NAME	SIC	YINV	PLLT	EST. EMIS	TONS/YR
ID	029	0001	A1	MONSANTO IND. CHEM.	ROUTE 34, 3 MILE	SODA SPRINGS	2819	88	SO2	7553.0000000	TY
	077	0006	A1	J.R. SIMPLOT COMPANY	HWY 30 & I86	POCATELLO	1475	88	SO2	7666 ~~7190~~.0000000	TY
	005	0004	A1	ASH GROVE CEMENT COMPANY	230 CEMENT ROAD	INKOM	3241	88	SO2	4095.3000000	TY
	077	0005	A1	FMC CORPORATION	HWY 30 WEST	POCATELLO	2819	88	SO2	2980.0000000	TY
	029	0003	A1	NU-WEST INDUSTRIES	CONDA ROAD	CONDA	2874	91	SO2	1339.9990000	TY
	027	0010	A1	AMALGAMATED SUGAR	KARCHER RD/NORTHS	NAMPA	2063	88	SO2	1304.0000000	TY
	069	0001	A1	POTLATCH CORPORATION	805 MILL ROAD	LEWISTON	2631	88	SO2	1146.9910000	TY
WA	041	0010	A1	PACIFIC POWER_& LIGHT CO.	913 BIG HANFORD R	CENTRALIA	4911	91	SO2	59416.0000000	TY
	073	0001	A1	INTALCO ALUMINUM	BOX 937	FERNDALE	3334	91	SO2	6235.0000000	TY
	063	0016	A1	KAISER ALUM & CHEM	E 2111 HAWTHORNE	MEAD	3334	91	SO2	5864.0000000	TY
	057	0005	A1	SHELL OIL	WEST MARCH POINT	ANACORTES	2911	91	SO2	4934.0000000	TY
	007	0001	A1	ALUM CO OF AMERICA	BOX 221	WENATCHEE	3334	91	SO2	4545.0000000	TY
	057	0003	A1	TEXACO INC	SO TEXAS RD & MAR	ANACORTES	2911	91	SO2	2962.0000000	TY
	071	0003	A1	BOISE CASCADE	P.O. BOX 500	WALLULA	2611	91	SO2	2650.0000000	TY
	011	0011	A1	VANALCO, INC	PO BOX 9805	VANCOUVER	3334	91	SO2	2491.0000000	TY
	073	0007	A1	ARCO INC	CHERRY POINT REFI	FERNDALE	2911	91	SO2	1883.0000000	TY
	053	0019	A1	KAISER ALUMINUM AND	3400 TAYLOR WAY	TACOMA	3334	91	SO2	1789.0000000	TY
	073	0005	A1	BP OIL COMPANY	PO BOX 8	FERNDALE	2911	91	SO2	1752.0000000	TY
	015	0002	A1	LONGVIEW FIBRE	BOX 639	LONGVIEW	2611	91	SO2	1663.0000000	TY
	053	0008	A1	SIMPSON TACO. KRAFT	801 PORTLAND AVE	TACOMA	2621	91	SO2	1248.0000000	TY
	015	0003	A1	WEYERHAEUSER CO	PO BOX 188	LONGVIEW	2611	91	SO2	1172.0000000	TY

TOTAL NUMBER OF LINES: 21

Big Baldy Mountain from Middle Fork Peak

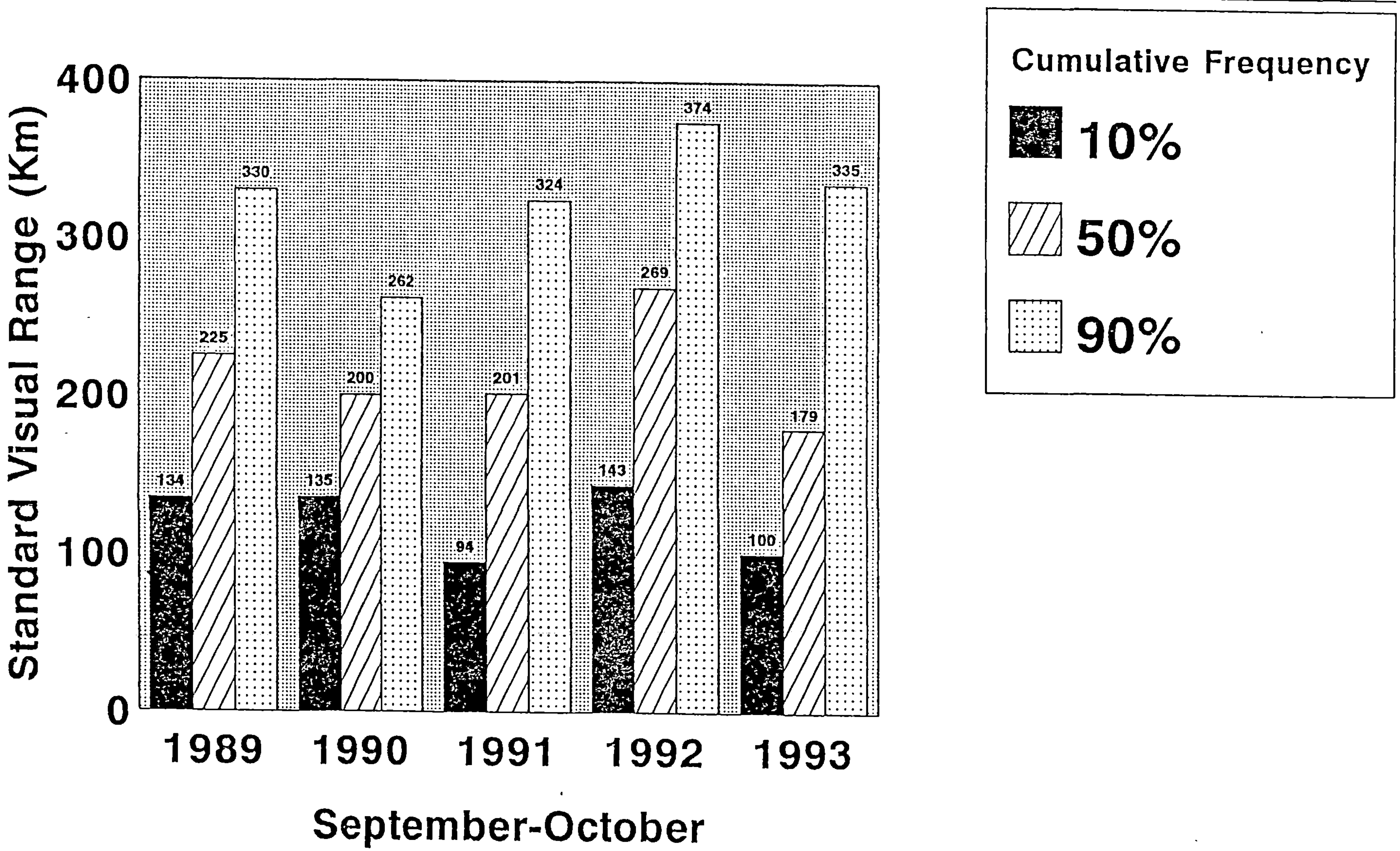
Visibility Monitoring of Frank Church--River of No Return Wilderness
Region 4, Salmon National Forest



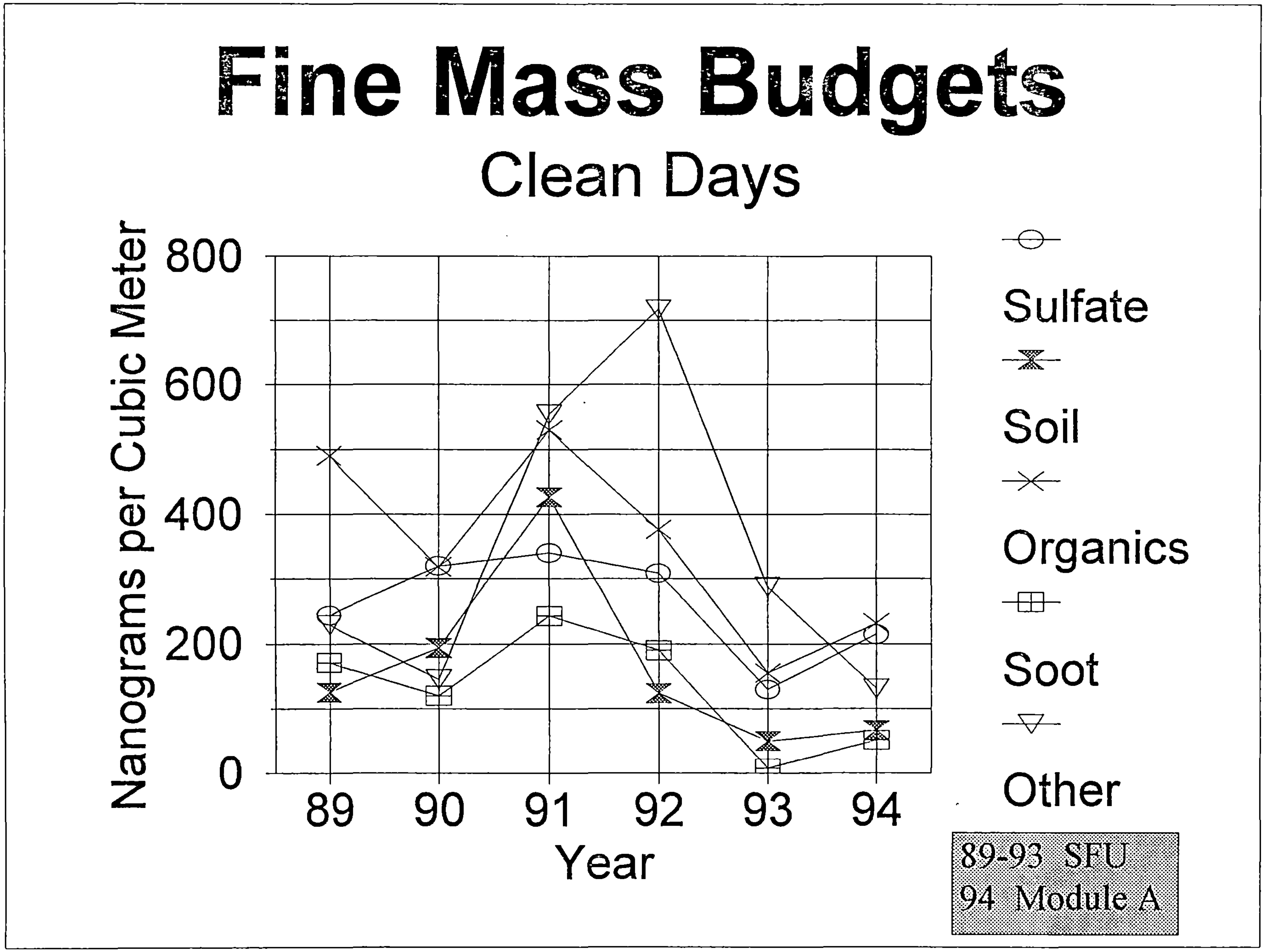
Big Baldy is 30 miles southwest of Middle Fork Peak

Big Baldy Mountain from Middle Fork Peak

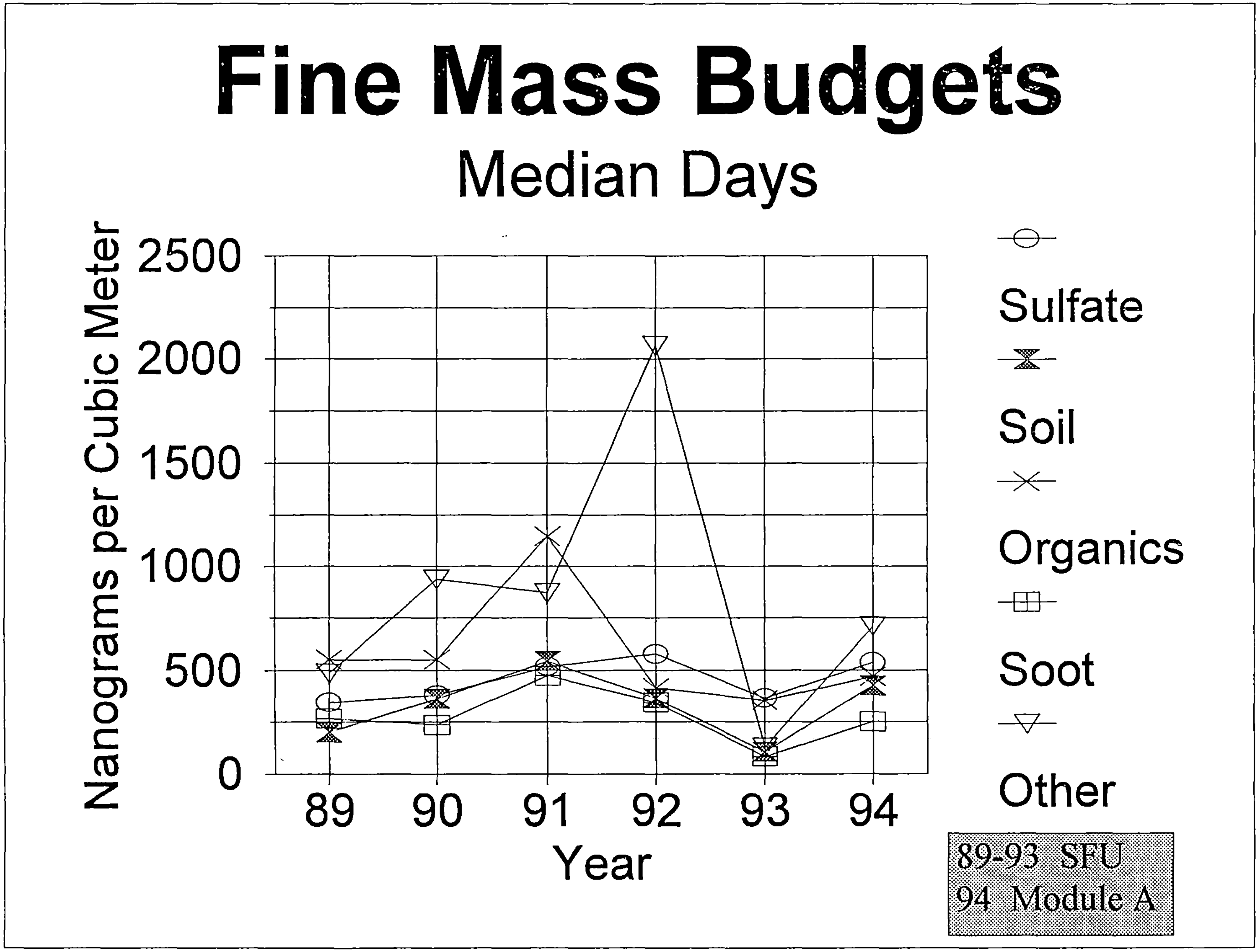
Visibility Monitoring of Frank Church--River of No Return Wilderness
Region 4, Salmon National Forest



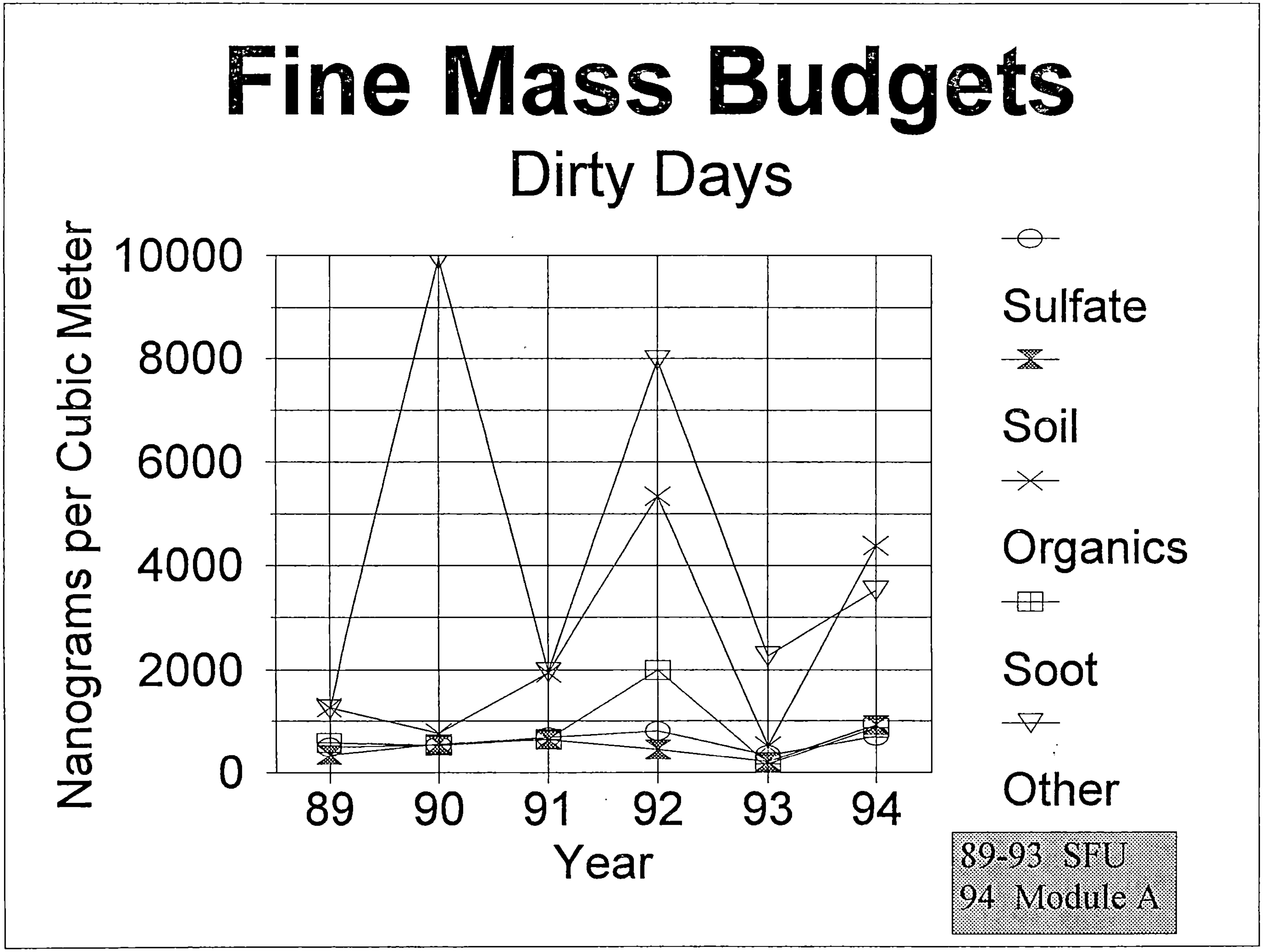
Big Baldy is 30 miles southwest of Middle Fork Peak



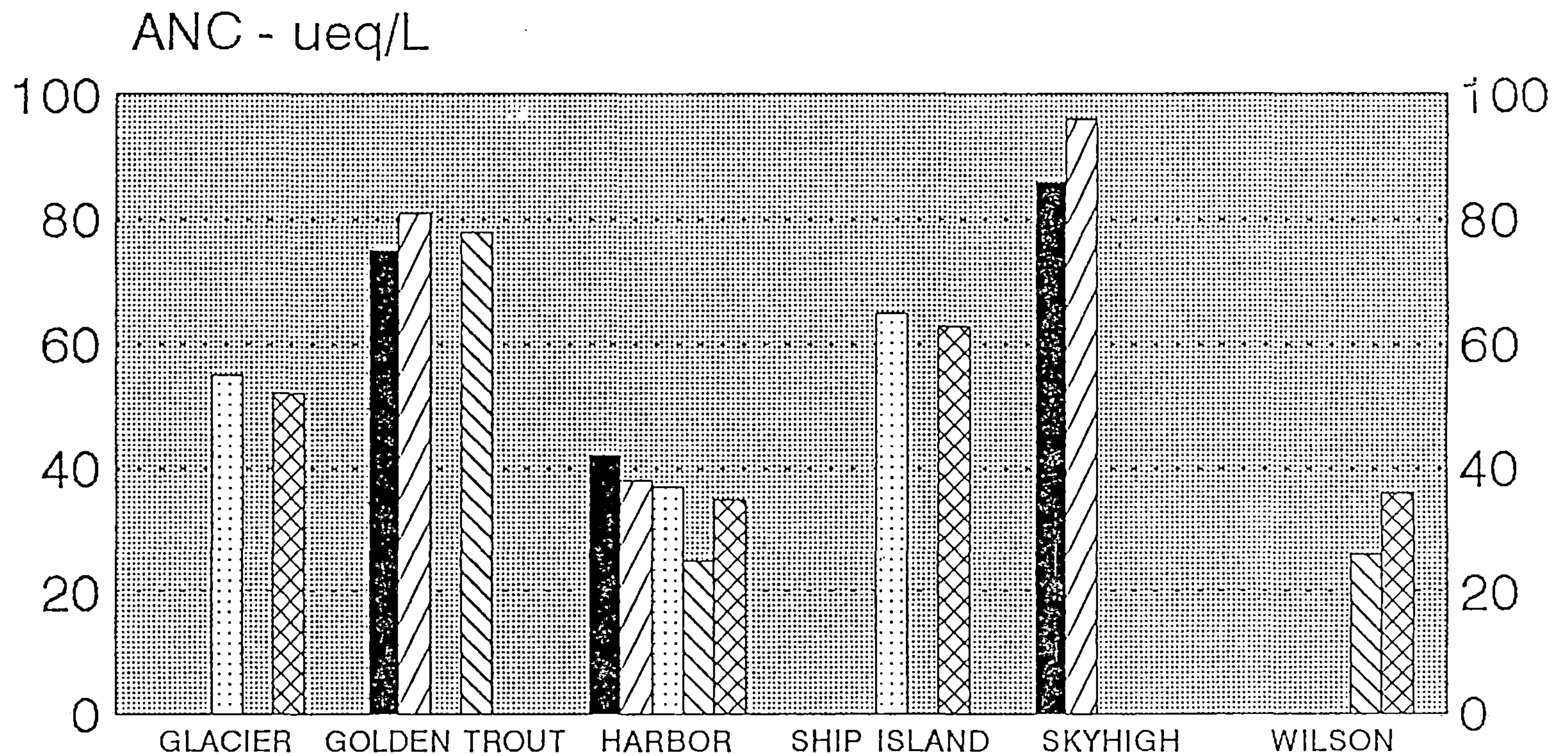
Fine Mass Budgets
Clean Days
Nanograms per Cubic Meter
800
600
400
200
0
89
90
91
92
93
94
Year
Sulfate
Soil
Organics
Soot
Other
89-93 SFU
94 Module A



Fine Mass Budgets
Median Days
Nanograms per Cubic Meter
2500
2000
1500
1000
500
0
89
90
91
92
93
94
Year
Sulfate
Soil
Organics
Soot
Other
89-93 SFU
94 Module A

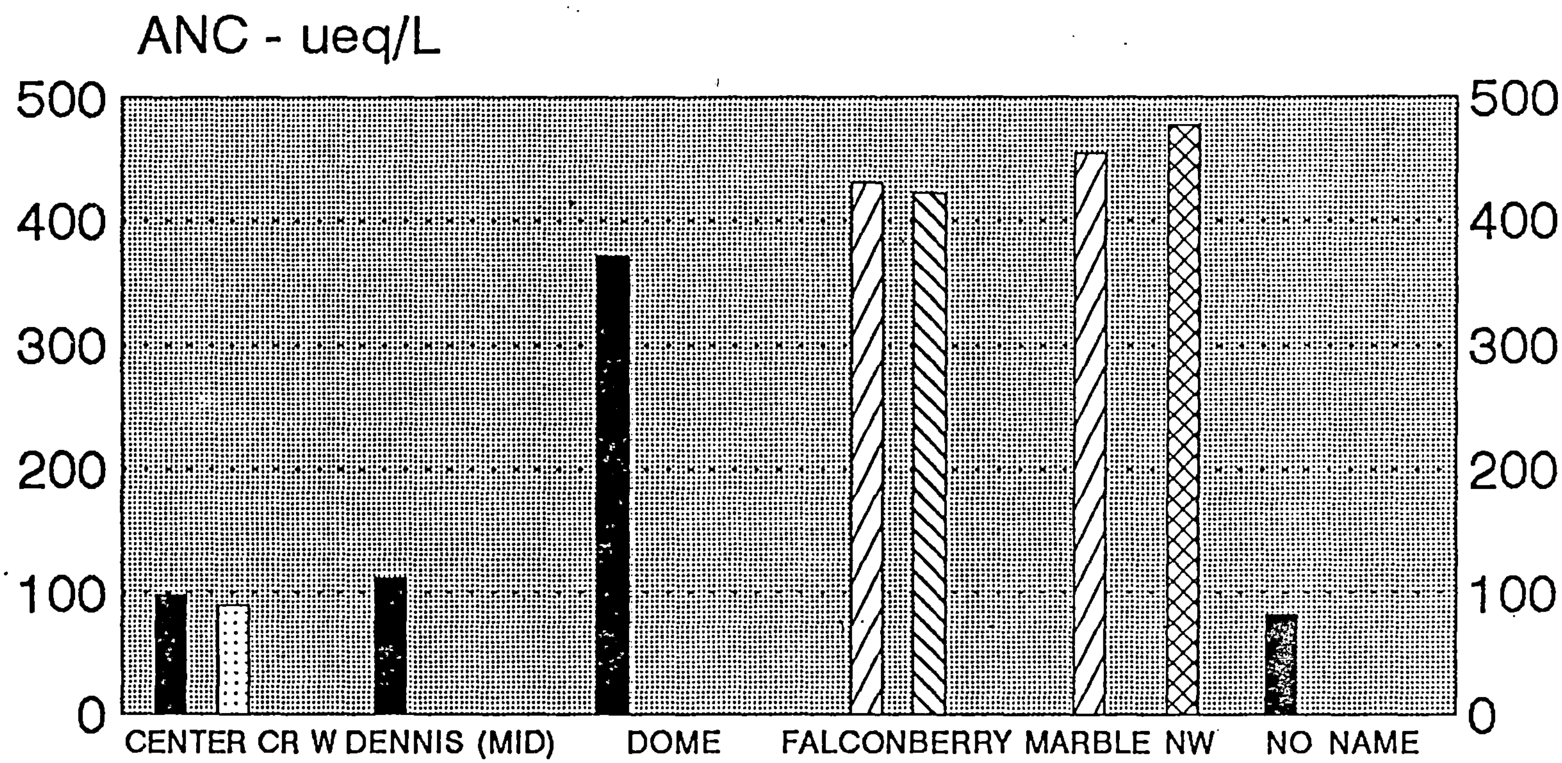

Fine Mass Budgets
Dirty Days
Nanograms per Cubic Meter
10000
8000
6000
4000
2000
0
89
90
91
92
93
94
Year
Sulfate
Soil
Organics
Soot
Other
89-93 SFU
94 Module A

ACID NEUTRALIZING CAPACITY
FRANK CHURCH-RONR WILDERNESS LAKES



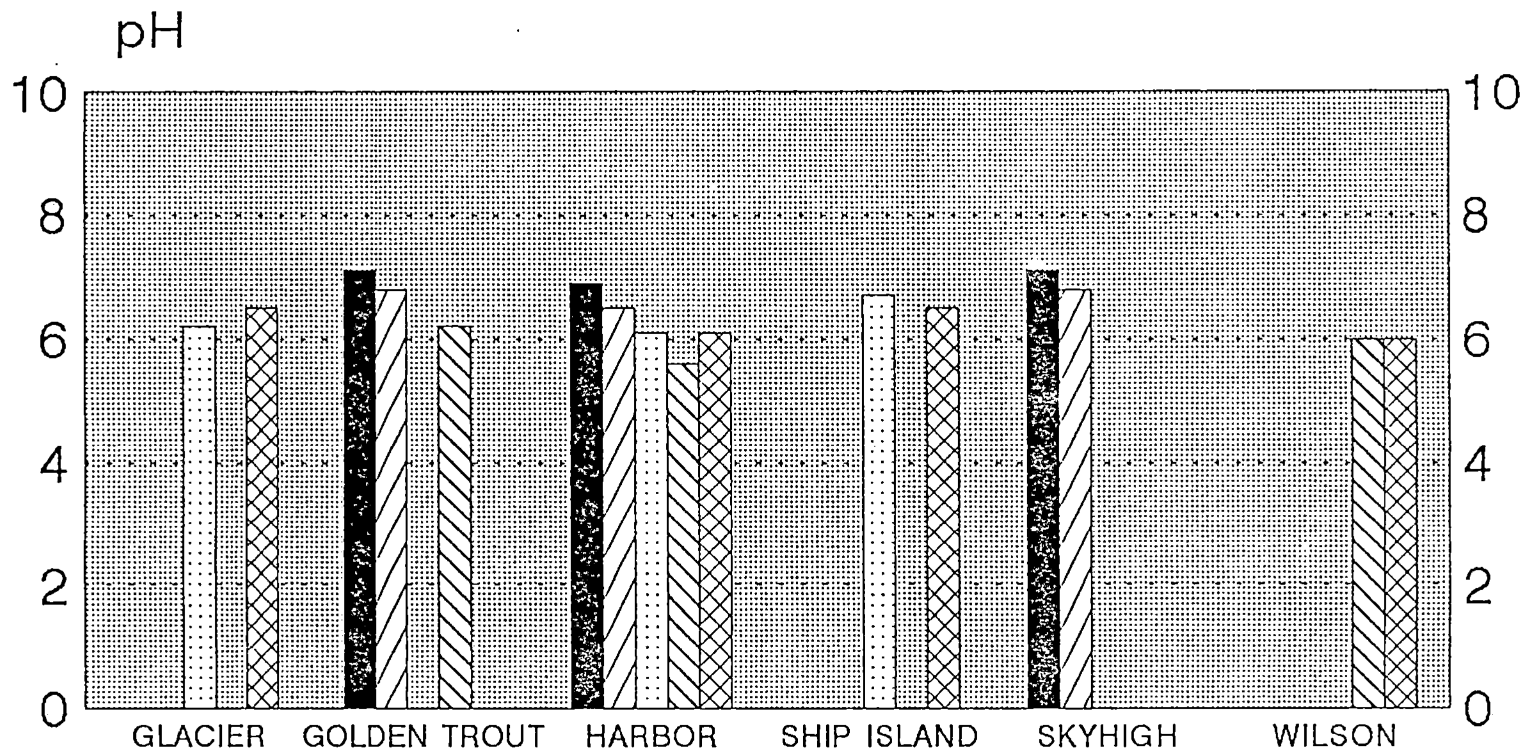
	GLACIER	GOLDEN TROUT	HARBOR	SHIP ISLAND	SKYHIGH	WILSON
SEP 85 (EPA)		75	42		86	
JUL 94		81	38		96	
AUG/SEP 94	55		37	65		
JUL 95		78	25			26
AUG/SEP 95	52		35	63		36

ACID NEUTRALIZING CAPACITY
FRANK CHURCH-RONR WILDERNESS LAKES



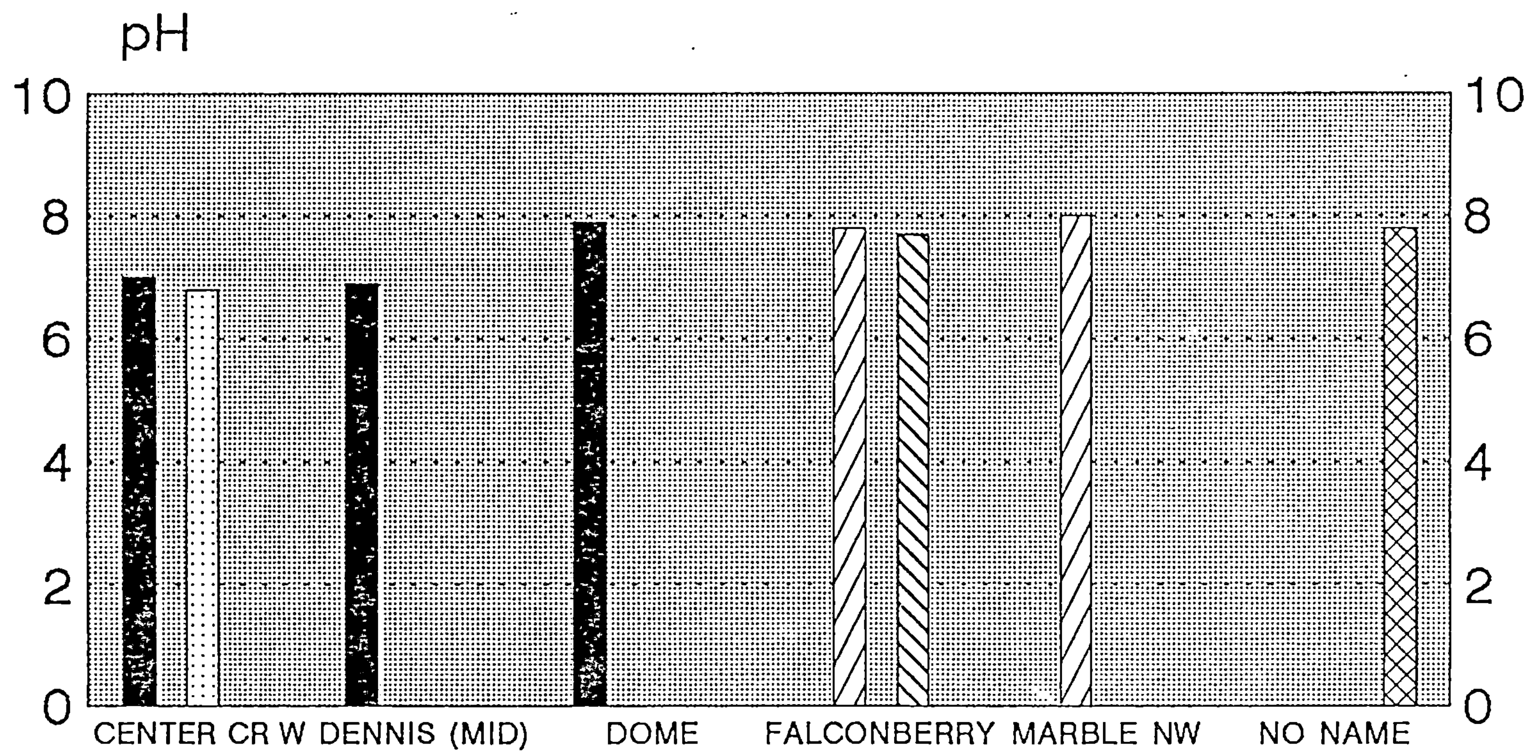
	CENTER CR W	DENNIS (MID)	DOME	FALCONBERRY	MARBLE NW	NO NAME
SEP 85 (EPA)	98	112	372			83
OCT 85 (EPA)				430	454	
JUL 89	90					
AUG 90				422		
SEP 90					478	

pH
FRANK CHURCH-RONR WILDERNESS LAKES



	GLACIER	GOLDEN TROUT	HARBOR	SHIP ISLAND	SKYHIGH	WILSON
SEP 85 (EPA)		7.1	6.9		7.1	
JUL 94		6.8	6.5		6.8	
AUG/SEP 94	6.2		6.1	6.7		
JUL 95		6.2	5.6			6
AUG/SEP 95	6.5		6.1	6.5		6

pH
FRANK CHURCH-RONR WILDERNESS LAKES



	CENTER CR W	DENNIS (MID)	DOME	FALCONBERRY	MARBLE NW	NO NAME
SEP 85 (EPA)	7	6.9	7.9			
OCT 85 (EPA)				7.8	8	
JUL 89	6.8					
AUG 90				7.7		
SEP 90						7.8

FRANK CHURCH–RIVER OF NO RETURN WILDERNESS
TABLE 1: LICHEN ELEMENTAL ANALYSIS

Sample No.	Species/Collection Site	1988 S%	1991-93 S%	K%	Ca%	1988 Cu	1991-93 Cu	CL	Ti	V	Cr	Ni
94	Letharia columbiana, Harbor Lake, Sample # 94	0.0655	n.a.	0.274	0.582	3.22	n.a.	537	59.5	n.d.	n.d.	0.896
95	Letharia vulpina, Harbor Lake Sample #95	0.0848	n.a.	0.314	0.424	3.31	n.a.	718	71.2	n.d.	2.35	0.81
96	Letharia columbiana, Harbor Lake, Sample #96	0.0721	n.a.	0.223	0.349	2.76	n.a.	626	71.1	n.d.	2.28	1.07
98	Umbilicaria vella, Garden Creek, Sample # 98	0.165	n.a.	0.483	0.368	5.06	n.a.	514	55.4	n.d.	n.d.	0,63
99	Letharia vulpina, Garden Creek Sample # 99	0.0567	n.a.	0.32	0.431	2.13	n.a.	526	41	n.d.	n.d.	0.113
227	Letharia vulpina, Garden Creek, Sample #227	0.025	1993 0.039	0.24	0.4302	4.9	2.08	134	39	5.2	0.82	n.d.
228	Umbilicaria vellea, Garden Creek, Sample #228	0.157	1993 0.15	0.5	0.167	11.1	8.4	230	200	11	1.9	2.3
104	Letharia columbiana, Golden Trout Lake, Sample # 104	0.0612	n.a.	0.224	0.458	3.13	n.a.	784	59.8	n.d.	3.85	2.89
105	Letharia vulpina, Golden Trout Lake, Sample # 105	0.0699	n.a.	0.241	0.8223	1.91	n.a.	963	38	n.d.	n.d.	0.64
222	Letharia columbiana, Golden Trout Lake, Sample # 222	0.056	1993 0.038	0.229	0.203	9.3	2.83	164	43.4	6.02	n.d.	0.256
230	Letharia vulpina, Warm Springs Trail, Sample#230	n.d.	1992 0.051	0.24	0.21	n.d.	2.5	230	52	4.5	1.3	0.9
231	Parmelia saxatilis, Warm Springs Trail, Sample#231	n.d.	1992 0.075	0.46	0.61	n.d.	7	1000	720	29	2.4	2.9
284	Parmelia saxatilis, Bernard Creek, Sample # 284	n.a.	1992 0.074	0.363	0.601	n.a.	7.65	959	397	12.2	6.14	4.54
286	Letharia vulpina, Bernard Creek, Sample # 286	n.a.	1992 0.0739	0.382	0.364	n.a.	2.27	516	61.6	n.d.	9.52	6.2
287	Letharia vulpina, East Horse Creek,Sample#287;along S.River	n.a.	1991 0.0554	0.252	0.16	n.a.	2.61	296	80.4	n.d.	13	7.07
288	Xanthoparmelia cumberlandia, East of Horse Creek,Sample#288	n.a.	1991 0.119	0.669	4.28	n.a.	9.24	1570	947	18.8	15.8	6.02
245	Letharia vulpina,Frog Meadow RNA, Sample # 245	n.d.	1992 0.069	0.295	1.16	n.d.	6.53	465	66.5	7.67	3.33	2.08

1988 - Atomic Absorption Method
1991 - 93 - PIXIE Method
S, K, Ca - in percent
All other elements in ppm

FRANK CHURCH–RIVER OF NO RETURN WILDERNESS
TABLE 2: LICHENS ELEMENTAL ANALYSIS

Sample No.	Species/Collection Site	1988 Pb	1991-93 Pb	Zn	Mn	Fe	Co	As	Se	Br	Rb	Sr
94	Letharia columbiana, Harbor Lake, Sample # 94	8.02	n.a.	39.1	180	438	n.d.	1.37	n.d.	5.21	3.99	38.5
95	Letharia vulpina, Harbor Lake, Sample # 95	13.5	n.a.	31.4	70.9	493	n.d.	2	n.d.	9.69	5.87	30.8
96	Letharia columbiana, Harbor Lake, Sample # 96	8.5	n.a.	23.8	88.2	541	n.d.	2.51	n.d.	7.03	4.04	22.8
98	Umbilicaria vellea, Garden Creek, Sample # 98	4.41	n.a.	101	53.2	612	n.d.	5.15	n.d.	4.63	4.08	34.4
99	Letharia vulpina, Garden Creek Sample # 99	5.87	n.a.	19.1	59.6	277	n.d.	2.16	n.d.	2.83	2.37	30.3
227	Letharia vulpina, Garden Creek,Sample #227	7.6	1993 2.17	21.7	61.3	146	n.d.	0.85	n.d.	5.02	1.12	24.02
228	Umbilicaria vellea, Garden Creek, Sample #228	11.9	1993 8	87	62	2100	n.d.	3	0.4	16	10	36
104	Letharia columbiana, Golden Trout Lake, Sample # 104	10.2	n.a.	29.4	121	386	n.d.	0.93	n.d.	6.02	4.81	25.7
105	Letharia vulpina, Golden Trout Lake, Sample # 105	6.88	n.a.	37.3	224	286	n.d.	1.84	n.d.	6.03	5.59	36.3
222	Letharia columbiana, Golden Trout Lake, Sample #222	9.1	1993 6.73	19.8	283	213	n.d.	n.d.	n.d.	9.31	6.25	18.1
230	Letharia vulpina, Warm Springs Trl, Sample #230	n.d.	1992 2.7	13	82	310	n.d.	1.3	n.d.	8.4	2.5	22
231	Parmelia saxatilis, Warm Springs Trl, Sample #231	n.d.	1992 21	40	160	5100	n.d.	3.57	n.d.	24	21	86
284	Parmelia saxatilis, Bernard Creek, Sample # 284	n.a.	1992 32.1	37.3	151	3270	n.d.	n.d.	1.01	14.8	9.32	60.8
286	Letharia vulpina, Bernard Creek, Sample # 286	n.a.	1992 6.59	28.7	154	526	n.d.	2.65	n.d.	3.84	n.d.	21.1
287	Letharia vulpina, East Horse Creek,Sample#287,along S.River	n.a.	1991 6.8	28.4	31.3	581	n.d.	n.d.	n.d.	3.88	2.04	10.7
288	Xanthoparmelia cumberlandia, East Horse Cr. Sample # 288	n.a.	1991 15.7	59.4	102	6880	11.7	2.73	n.d.	13	27.5	140
245	Letharia vulpina, Frog Meadow, RNA, Sample #245	n.d.	1992 7.42	119	302	426	n.d.	0.86	n.d.	6.29	3.75	57.9

1988 - Atomic Absorption Method
1991 - 93 - PIXIE Method
S, K, Ca - in percent
All other elements in ppm